THE MARCH SCIENTIFIC MONTHLY

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J. McKEEN CATTELL, F. R. MOULTON AND WARE CATTELL

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THE SCIENTIFIC MONTHLY

MARCH, 1939

RESEARCH IN INDUSTRY

By Dr. FRANK B. JEWETT

PRESIDENT OF THE BELL TELEPHONE LABORATORIES

ALL the fundamentals of industrial research—whether of research itself, its management, the relations of it to the other activities of the business of which it is a part, or to the success of that business—are in fact few. When it comes to the recital of the specific achievements of research the case is different. In this field one can expound *ad lib* since there is always fresh material in the silk hat.

In a sense research in the world of physical things, even as we define it today, is as ancient as man himself. Every curious man who sought by trial to know why or how something behaved as it did was a research worker. If he was satisfied with the knowledge he derived from his experiment or if he merely imparted it to others of the clan, he was an embryonic fundamental scientist. If, however, he sought to employ his new knowledge to the making of a better tool or weapon, and more particularly if he was impelled to make his trial because he might thereby achieve that end, he was an ancient progenitor of all present-day industrial research men.

Strictly speaking, however, research in the physical world and more particularly industrial research are very young in terms of human experience. As major factors in influencing social thinking or acting they are scarcely more than a century and a half old. Industrial research, which is the offspring of fundamental research and collective effort through organization in industry, has been a force in the world for little more than fifty years. Conscious training of men for it is younger still, having developed well within my lifetime. Few, if any, of us older industrial research men were ever aiming for a life in industry when we sought training in basic science.

Because of its youth and the number and variety of this new child's characteristics, it is small wonder that society is bewildered and occasionally alarmed and resentful. While business has made a good deal of progress in the direction of abandoning its earlier attempts to ignore the child or force him to conform to ancient tribal customs, society generally and politics especially still persist in a determination not really to understand him; this despite the fact that they have gone far enough to like the new things he brings home. At times they go so far as to appropriate his language, even though their knowledge of what the words mean is a bit hazy.

The principal thing which distinguishes the world of the past one hundred fifty years from the ages of human history which preceded has been the wide-spread acceptance of the so-called scientific method as the best, most powerful and most expeditious means of exploring the unknown, and the results that have followed that acceptance. Fundamentally it is nothing but an idea —the concept that the surest way to test

a hypothesis is to subject it to a succession of simple controlled experiments, each of which can be repeated at will, and to be guided rigorously by the results. To be successful its votaries must observe strict intellectual honesty. Recent history shows that in this concept man has hit upon one of the most, if not the most, powerful tools for change ever created.

The scientific method and the techniques which have been evolved under it are infinitely more powerful than any methods of abstract reasoning or dialectics. Applicable theoretically in any sector of inquiry, the scientific method is obviously easier of full application in the realm of the inanimate physical world than in those which involve animate things. This is not so much because the problems here are less complex than elsewhere. Rather it is because of the greater ease of conducting really controlled experiments.

One thing that the successful research man learns early in his career is the application to physical science, whether fundamental or applied, of the old axiom of mathematics that there must be as many independent equations as there are unknowns if he is to evaluate the unknowns. Another thing he learns early is that failure of a controlled experiment to work out as expected is not really failure but actually a step forward. It enables him to modify his preconceived ideas and organize another experiment. One of the commonest and frequently one of the most tragic errors of society is to draw definite conclusions from experiments where many factors are not under control. In such an experiment it is a matter of pure chance if proper conclusions happen to be drawn. Even then the presence of other factors than the one claimed to be dominant is an invitation to unending wrangling. I am sorry to say that many so-called engineering experiments are of this character. That is why we so frequently use such large "factors of safety"—really factors of ignorance in applying our results.

Viewed in retrospect, the development of industrial research during the past forty years appears as logical and inevitable as the development of science itself. When at the beginning of the century the first timid adventures were being made by a few industries with a handful of young men lured from the ranks of teaching, the scientific method was already firmly established in the domains of physics and chemistry. Brilliant results in the form of new knowledge had already been obtained, and some of it had been put to work by clever inventors and engineers. Only the young and venturesome were attracted to the new field, since the traditions of the university then were strongly against anything which tended to sully the quest of knowledge for its own sake. Although he relented somewhat with time, I think I never quite regained the respect of my old chief, Professor Michelson, after I forsook the halls of learning for the walls of industry.

Many of the newer industries which had grown up in the 80's and 90's were the first to sense the need of something more than was provided by men of ingenuity, inventors and engineers. Principally, they were in the fields of applied electricity and modern chemistry. In them the control of tradition and art was weakest or substantially non-existent. Further, all the personnel was relatively young and inclined to be daring—social security as the inalienable right of all had not yet been heard of.

In a few of these industries progress had been such that problems beyond the ability of inventors and engineers to cope with had arisen. In others it was felt that if only some known fragments of new knowledge could be pieced together and applied, much greater progress

could be made. A few wise men saw that in both circumstances hope lay in introducing into industry the rigorous methods of fundamental science and men trained in their operation.

The innovation worked—in some cases far beyond original expectations. It grew upon what it fed, and as one astounding achievement after another came to be known and publicized the virus spread. Gradually but with increasing acceleration more and more industries based on science came to incorporate more or less of industrial research into their organic structure. Mainly at first the expansion was to industries in the fields where the trial started, *viz.*, those of physics and chemistry and to those of more recent origin. Industries which were ancient arts before modern science was born were the last to make the plunge despite the fact that in many cases they were most important to society and had most to gain from the new method.

As time went on and the results of the scientific method began to pile up hills and mountains of new knowledge in the domains of biology and botany, the intrusion of industrial research organizations took place in industries in these fields. The whole evolutionary process in industry put pressure on the institutions of learning from which alone could come the army of trained men and, to a large extent, the streams of new knowledge needed to supply power to their mills. The pressure was from two directions—from industry's demand, on the one hand, for more and better men than could be supplied by kidnapping from the ranks of the fundamental science scholars, and on the other from youths who, with no desire to become academic scholars, were nevertheless avid for exactly that training as a basis for life in the new realm of business and industry.

We all know that the response of university and technical school alike was wholehearted and efficient. While there are, I suppose, still some in academic circles who profess to see something akin to prostitution of scientific research in the thought of employing it for anything save the acquisition of knowledge for its own sake, their number must be small. Certainly in recent years the great majority of men in training have had their eye on a life in industry.

The World War gave a great impetus to meticulous industrial research and the decade of the 1920's witnessed a veritable stampede of industries, large and small, to climb on the band wagon. These ventures ranged all the way from well-considered undertakings, which have lived and prospered, to foolish things undertaken in all sincerity but with complete ignorance of what was required either by way of personnel or coordination. Most of these last have quietly folded up and disappeared. So too have many of those which with no ethical justification were created in name only for the purpose of cashing in on the popular esteem in which industrial research had come to be held.

Looking back over the history of industrial research to judge its relation to business success, one thing stands out in every case with which I am familiar, namely, the hard internal sledding of the initial years. Barring possibly some of the newest industries which have sprung directly from the research laboratory, that is, where *it* was the parent rather than the child, the first years of every real research organization have been soul-trying years. This was so even in the early cases already mentioned, where there was as yet little or no tradition or art. Even here the existing organization was one of "practical" men and per contra the intruders (for such they were looked upon) were "impractical" theorists. I suppose it is bound always to be so.

The first big job was to sell the new

idea and to acquire that confidence and respect without which nothing could be accomplished. Those who tackled too much at the start were properly and rightly hazed. The wise ones took their time and started by picking out problems which were easy from their standpoint but which had the "practical" men half crazy with insomnia.

In the early days nothing was known of just how best to relate the research activity to the other parts of the business organization, and every conceivable arrangement was tried. Frequently it was made a part of the existing engineering department. Sometimes it was set up as a thing apart from all else as a sort of free lance consulting affair tied into the main organization through some superannuated vice-president to whom it seemed desirable to assign more work. All kinds of arrangements are still to be found, but in the main they are no longer haphazard but have some justification in reasons peculiar to the particular industry of which they are a part.

In some of the larger industries which have had long experience with research, where the function has attained large proportions and where the corporate set-up involves a number of more or less autonomous companies, as is the case with the Bell System, General Motors and a number of others, the research laboratory is now set up as a legal corporation. The presidents of these research corporations are part of the general directing management and so bring to it first-hand information.

In other industries, where for one reason or another the corporate form of organization has not been adopted, despite the size and importance of the research function, the research director is nevertheless a part of the administrative management, either under that title or the title of vice-president and research director.

Either of the arrangements just mentioned has the advantage over others in that the responsible head of the research organization participates directly in the consideration of matters affecting company policy. In some industries many important policy decisions are vitally affected by exact information on the present and prospective state of the art as viewed through the eyes of the research department.

Any form of organization which interposes one or more links between the research director and the top management inevitably tends to dilute or distort this information. Conversely, the research organization tends to be deprived of valuable information connected with company affairs which may have a distinct bearing on the trend of current work.

The men who are now research directors, under whatever title, were originally research workers and creative producers. This is particularly true in the larger research organizations where the demands of administration, broad decision and a thousand and one things which consume time leave little opportunity for individual participation in creative work. To any one interested in appraising the value of research in industry this fact is one of some importance, since it tends to refute a very common misconception. This misconception is that the activities of the research department are determined by the director and carried out by his associates. In a very general sense this may be true in so far as the views of the director operate to determine broad fields of inquiry. Beyond this he frequently has little concern with or influence on the details of research investigation, and his most active participation in the day-by-day creative work is likely to be that of a critical appraiser who brings to bear upon results obtained the benefit of broad knowledge and long experience.

One of our most distinguished research directors once said, somewhat facetiously but with a good deal of truth,

that if one wanted the best possible appraisal of the prospective value of a new research development he would consult the man who had done the work. Next in line would be the supervisor of a group of related research activities and finally the director of the laboratory, but never a vice-president unless perchance that vice-president happened to be the research director just mentioned.

What I have just said does not mean that industrial research laboratories should be left to function in their own sweet way, nor that the general administrative management has not a very great concern in them. Management must from time to time decide how much money can properly be allocated to the conduct of research and in what general directions that research should be pursued. The research director as a part of management is responsible for setting still more accurate sailing directions. What I am attempting to say is that the farther one gets away from the actual doing of research, which is an individual creative act, the less likely is it that the detailed direction of work will be wise and the more likely that it will be influenced by factors of immediate expediency. This is, I think, particularly the case with investigations on the frontier of the field involved—investigations which if successful are likely to be many times more valuable than those concerned with nearby advances in the art.

Before leaving the matter of the general set-up and operation of the industrial research laboratory there is one further conclusion which it is generally agreed has resulted from past experience. This is that of all the integral parts of industry the research department is the one which can probably be least safely tampered with in times of violent business fluctuation. I say this not because research men are entitled to more consideration than others, but simply because the productiveness of an industrial research organization is drastically affected by anythng approaching violent fluctuation in personnel or policy. The most important problems with which the research organization is concerned are complicated affairs which require the cooperative action of a considerable number of scientists long trained in the field of their special interest and accustomed to working together. A too sudden growth or a too sudden curtailment of the research force affects its productivity out of all proportion to the change in numerical numbers—this irrespective of the inherent caliber of the individuals added or subtracted.

As a matter of fact experience in many fields has shown more frequently than not that the most valuable contributions of industrial research are made at times of depressed business activity. The reason for this I will touch on in a moment.

Summed up, what I have just said might be stated somewhat as follows. If business wishes to obtain maximum value from its research organization and for the money it expends on it, it must be prepared to guard these expenditures against a too direct influence of current business variations. It must be prepared to expand or contract research activity as far as possible in conformity with more fundamental factors, otherwise it will lose much money in unproductive effort.

The current activities of every industrial research organization are always of two kinds, although the relation in the amount of the two may vary widely from time to time. On the one hand, is the work of a fundamental character on problems which, if successfully solved, will be of advantage to the industry at some more or less distant future time. This work having little or no relation to the current operations of the industry, is usually of paramount value. Every research director struggles mightily to maintain this type of work at a maximum.

On the other hand is work concerned with the problems of current operation. This type of work arises either because the research laboratory is set up to do it or because problems arise in current operation which are beyond the capacity of the operating people, including works laboratories, to cope with. The research organization is then appealed to for assistance and simply can not resist extending help, even though at the expense of more valuable long-range investigations. The number and urgency of such problems are of course greatest in times of intense business activity, and in consequence the amount and to some extent the efficiency of work on fundamental problems are least at these times.

Fortunately it is relatively easy for trained research men to shift from work in one category to that in the other. The mental processes, the techniques and the skills required are essentially the same; hence the statement made a moment ago, that in many cases the most valuable fundamental work is accomplished in times of low business activity, for it is then that the research organization is least bedeviled by urgent demands for assistance in the operating departments and has maximum man-power to apply.

Coming to consider more specifically the relationship suggested in the title, even a cursory review of modern industry can not help but disclose a close relationship between extensive efficient industrial research and success in the business to which it is attached. Among industries based on applied science we find those to be most successful in which the research function is large, relatively old and where its place in the business structure makes it an integral part of executive management. No better proof could be wanted that many successful industries have come to realize the importance of research to continued successful operation and maintenance of prestige.

If we examine further the internal composition of these industries we find increasing evidence of an indirect influence of the research organization in the number of men who, starting in the research laboratory, have been transferred to the operating departments. This transfer is most noticeable in the case of radically new developments which have grown out of research attack. Where such new things are to be put in commercial production or operation it is almost inevitable that this transfer should take place.

This phenomenon suggests an indirect influence of research on business success which I sometimes think is equal to if not greater than many of the direct benefits. As one looks back over the changes which have taken place in business operations during the past two or three decades, he can not, I think, escape the conclusion that more and more of the non-technical problems are being approached from the scientific point of view and so far as is feasible under controls of the scientific method. In part this is doubtless the result merely of emulation of the methods employed so successfully in physical research. In part the tendency is doubtless the result of the infiltration of men from the research laboratory who have carried their special methods of thought into new fields.

The most obvious contribution of the research organization to success in business is the thing for which it ostensibly exists, namely, the creation of new things. But no research organization, however extensive or competent, can hope to guarantee to its industry production of all new ideas. When such ideas, and particularly those of a radical nature, arise outside the industry and are presented to it for consideration, it is more frequently than not the knowledge possessed by the research department which enables management to determine its proper course. This is particularly true when patents are presented, for then

management is limited in its courses of action. It must either decide to acquire rights; to develop alternative ways of accomplishing a similar end; or to discard all thought of usage. Ofttimes the research department can give almost immediate advice. At other times it can at once perform the necessary examination needed to produce the answer. Likewise, and this more frequently than not, it will be found that in the existing work of the laboratory—work which is itself protected by patents—there exists the currency with which to purchase freedom of use if such purchase is indicated as necessary—a purchase which might not be possible with money alone.

Every business undertaking is fraught with more or less risk. This is true both as to the overall operations and to the operation of the various departments as well. Long observation has convinced me that of all its new operations those based on the results of research are by far the least hazardous with which business has to cope. In saying this I refer to the hazards of technological error and not to the hazards of error in commercial judgment which cause business to embark on an otherwise sound venture at the wrong time or in the wrong place. The reason for this feeling is based not on any idea of superior intelligence among research men but upon the fact that scientific research tends to eliminate error. Each error as it is found is corrected, with the result that the chance of gross error at the end is almost non-existent. I can not recall a single major failure of a project based upon adequate research. The few I remember which were attributed to the research organization were found on examination to be due to failure of the manufacturing or operating departments to observe *exactly* the controls specified. There is always an urge to do just this in order to save time or cost.

One essential and last step in the research method is the "trial installation"—a trial of the new things under rigid observational control of the laboratory under actual service conditions and on a scale sufficiently large to be a fair operating test. Many things inherent in large-scale operations can not be duplicated in the laboratory nor can man's infinite capacity for finding ingenious ways to cause trouble always be forecast. Sometimes nothing untoward develops, but sometimes costly errors are guarded against.

No trial installation is ever undertaken until all reasonable work has been completed in the laboratory, since it is an axiom of industrial research "That what *can* be done in a test-tube *may* be done on a large scale, but what can not be done in the test-tube can not be done commercially."

The money and time consumed in trial installations makes them frequently the most trying thing with which the research director has to deal, particularly when the new thing is most attractive and has given little trouble in the laboratory. Management then is like a boy in the presence of green apples—it yearns to pick the fruit before it is ripe.

Now finally a word about the future as I see it. As a result of forty years' experience research is firmly intrenched in the structure of many successful industrial undertakings. With them it is proven as a principal—in many cases *the* principal—insurance to continued success. Have we already exhausted most of its possibilities? The answer seems clearly "No."

In the first place there can be no question as to the power of the method to produce positive results. Likewise there are still considerable sectors of business where research is as yet embryonic or non-existent, but in which the conditions are identical with those where it has proven successful. This is especially the case in small industries and in those of ancient origin. In the one the problem

is that of selecting some form of cooperative undertaking among concerns similarly placed or of developing more institutions like the Mellon Institute. In the other it is the problem of breaking down age-old inhibitions.

More persuasive still is the picture of what is going on in all the domain of fundamental science where the research method is universally applied. The stream of new and potentially useful information which is flowing into our world of knowledge is stupendous and there is no end in sight. If it is to be used successfully by industry it can only be by a continued application of research in business. Man is and doubtless will remain an inquisitive and acquisitive animal.

What we will do with the new and cheaper things we create or how we will regulate and control that use is another question, speculation on which is outside the scope of this talk. But I would venture the suggestion that to solve the great underlying problems which will confront society in the years ahead we will require investigations undertaken on a far vaster scale and—having in mind our political theorizing—in more orderly fashion than we are now accustomed to. We need not here speculate as to the best auspices under which to make the attack—whether by enormous private undertakings or by action of the state or by a combination of the two. These underlying problems arise largely from what we humans have done in a material way these past 150 years. Broadly speaking, we have been prodigal in a free use of nature's stores without more than a speculative concern about what we would do when the stores were depleted. I doubt if we could have done otherwise. To cite but a few examples—we have exhausted soil fertility, which nature unaided can not restore; we have destroyed forests and have consumed minerals which nature will not replace. Our whole present civilization is primarily grounded in the use of natural products. Each step forward that we have made has increased our demand for mechanical power and accelerated our drain on the natural supplies which were accumulated through long geologic ages.

On the other hand, in our progress we have learned how to make many blades of better grass grow where one poor one grew originally; we have learned how to expedite the restorative processes of nature; how to make and employ substitutes and how to create usable power in ways nature never employed. And although much of our knowledge is in the laboratory test-tube stage, we do see a way out and can extricate ourselves and go forward if we have the wisdom and will to follow the charted course which scientific research indicates. There is no reason to believe that the problems of waste land from forest operations; of depleted fertility; of crops for other than food purposes; of low-grade ores, or of substitutes for metals and materials now showing signs of exhaustion, can not be solved; and fuel in abundance also—first probably through utilization of the billions of tons of lignite and low-grade bituminous coal, and later possibly from conversion through chemistry of the sun's energy stored up annually in growing things.

As I look at the problems ahead from the background of the past, it seems to me that so far we have made a great many trial installations in preparation for the bigger job ahead.

MENTAL DISEASE—A CHALLENGE

By Dr. WINFRED OVERHOLSER

SUPERINTENDENT, SAINT ELIZABETHS HOSPITAL, WASHINGTON, D. C.; PROFESSOR OF PSYCHIATRY, GEORGE WASHINGTON UNIVERSITY SCHOOL OF MEDICINE

MENTAL disorder is a subject which merits the attention of every intelligent citizen, for it constitutes to-day one of the largest and most pressing social problems. It is important from the medical, public health, social and economic points of view. Very nearly one half of the hospital beds of the entire country are devoted to the care of mental disease. At the beginning of the year 1936 there were, in the United States, 469,100 patients in mental hospitals or on visit to hospitals, and during the year following that date 150,208 others were admitted. Thus, during that year (1936) well over 600,000 people were at some time or other patients in a mental hospital—in other words, one out of about every 150 adults of the general population!

The investment in mental hospitals in this country is approximately one half billion dollars, and the annual cost of the maintenance of these institutions is about one hundred million. The wreckage of human lives, with the accompanying loss in productivity to the community, and the untold heartaches caused to the families of mental patients, can not be fully estimated or expressed in monetary terms. One need only mention, too, the bearing of mental disorder upon dependency and delinquency. There certainly are relationships here which are difficult to evaluate but which are none the less real. To bring the matter somewhat more closely home to the reader, it may be pointed out that it has been estimated from the statistics of the New York mental hospitals that the probabilities are that of all persons in New York, at least, fifteen years of age or over, one out of every twenty will at some time during his life be a patient in a mental hospital.[1]

In spite of the vital importance of the topic of mental disorder, there is probably no subject on which more misconceptions of facts are prevalent among the public and even among many educated people. When it is borne in mind that for countless centuries, from the time of Christ or earlier down through the Middle Ages, mental derangement was interpreted as due to demoniac possession, presumably as a punishment for sin, it is perhaps not strange that relics of the medieval attitude still hold over in the form of a disguised fear or hatred or contempt of the mental patient. Many persons even to-day are inclined to look upon the existence of mental disorder in a relative as a "stigma," as something to be kept secret, even though intellectually they may recognize that it is simply another manifestation of disease, and no more cause for shame than the occurrence of, let us say, pneumonia. The lot of the mentally ill person has never been a happy one, but for too long a time in man's history and, indeed, even to-day in some parts of the United States, that lot has been and still is being made more unhappy by man's inhumanity to man.

Institutions for the care of the mentally ill are relatively new things. During the Middle Ages and the early Renaissance these unfortunates were driven out of communities to perish miserably or were executed as witches. The

[1] A convenient synopsis of the statistics and their interpretation is to be found in the recent volume of Landis and Page entitled "Modern Society and Mental Disease."

Bethlehem Hospital in London was founded probably in the thirteenth century and has had a continuous history since that time, but for centuries after its opening stood alone as an "asylum" for these unfortunates. Parenthetically, it may be noted that the word "bedlam" is a corruption of Bethlehem, the name of this hospital. One can well imagine the reasons why when it is realized that only the "furiously mad" were confined in institutions, that little or nothing was done for them even in the line of elementary hygiene, and that these places were scenes of the worst types of filth and confusion.

The first public mental hospital in this country, at Williamsburg, Virginia, was founded in 1773, but it was not until the middle of the nineteenth century that the practice of building public mental hospitals became general, thanks to the activities of Dorothea L. Dix. The purpose of these institutions, which were then known as asylums, was primarily to care for the "furiously mad," as they were denominated. The more quiet patients were often cared for in jails or in almshouses, a situation which is not unknown in some parts of this country even to-day. It may be pointed out and emphasized that mental disorder was early looked upon as being of public interest only in connection with the disturbance of the peace or with "pauperism"; it was a subject to be dealt with by the police or by the poor authorities, not as a medical problem. Historically, these facts are probably connected to some extent with an attitude not entirely unknown, that mental disease impresses some sort of "stigma" upon the person who suffers from it and upon his family. Indeed, even to-day in many parts of the country the mental hospitals are under the control of departments of public welfare; that is, under organizations which are designed primarily to deal with the dependent, rather than raised to the dignity of recognition as medical institutions. The development of the medical attitude toward mental disorder, the attitude that we are dealing with disease which should be treated by physicians and which is amenable to treatment, is relatively recent. It is this evolution which has brought about the change of name from "asylum" to "hospital," with all that that name implies.

In the early days in this country admission to mental hospitals was not especially difficult, although those who were able to pay for care avoided, so far as possible, being sent to the public institution. The "asylum" was designed, as we have said before, primarily for "paupers" and for those who had been considered dangerous to the public peace. In the beginning hospital admission was a simple matter, but in the '50's the "railroading myth" seems to have become established. As a result of the fear that persons would be improperly sent to mental hospitals and there detained for the purpose of permitting others to obtain control of their property, the admission to mental hospitals was in a good many states made decidedly difficult, and some went so far as to require a trial by jury on a charge of lunacy before the patient could be admitted to the hospital. Such a barbaric and antiquated procedure was abolished by statute in the District of Columbia only as recently indeed as 1938, and is still retained in at least one state. There are many people to-day who believe seriously, in spite of the overcrowding and the constant pressure by hospital administrators to dismiss patients from hospitals, that patients are actually sent to such institutions improperly. Any one who has had experience in the administration of mental hospitals knows that this is a most

untrue accusation, yet laws still exist which make it difficult for patients to enter mental hospitals, although admission to any other kind of hospital is very simple. When admission is made difficult, and particularly when a jury trial (which often appears to the patient and to the public both to be in the nature of criminal proceedings) is necessary, admission to a mental hospital is delayed and often the best chance of cure of the patient is lost. The existence of the popular notion of "railroading" has done much to delay the early admission of patients and thereby to deprive the mental hospitals of one of their proper functions. Again it should be pointed out that in some localities it is permitted to use the jail for temporary care of mental patients until such time, sometimes several weeks or months, as the mental hospital finds room for the patient. Such proceeding is, of course, seriously out of line with sound practice and is grossly unfair to the mentally afflicted patient.

Some of the feeling that mental disorder is something apart from general medicine, that it is something which labors under a stigma, is perhaps due to the way in which psychiatry has been presented and in which in the past mental hospitals have been operated. There was a time when the asylum with its forbidding wall made no effort to overcome in the community the attitude of suspicion which was directed toward it by those ignorant of its activities. The "asylum doctors" were looked down upon by the physicians in the locality and an atmosphere of hocus-pocus and of something mysterious tended to keep people away from the institution, both physically and mentally. In medical schools the student was given the impression that mental disorder was something not akin in any way to the rest of medicine; the lectures were the most sketchy and sometimes not even accompanied by a visit to the mental hospital, with the result that physicians have in the past not been in a position to assist in breaking down the public distrust. To-day we find psychiatry integrated with the rest of medicine in medical training. We find medical students spending much of their time in mental hospitals, working at close quarters with the patients and coming to realize that psychiatry is something which touches every other field of medicine. They realize, too, from what they see in the institutions that they are not the places of horror and misery which some even to-day seem to consider them. Further, many general hospitals are establishing psychiatric wards—a decidedly salutary step in bringing psychiatry and general medicine into closer union.

Another misconception has been that once a patient was admitted to a mental hospital all hope was lost, and there are many who think that the inscription described by Dante over the gates of the Inferno is written, even though invisibly, over the entrance of mental hospitals. Such is, of course, far from the case. Mental disorder does not warrant the attitude of hopelessness which the public ascribes to it, even though certain types of mental disorder have not so favorable a prognosis as have others, and although in general mental disorders tend to take somewhat longer for their cure than do the disorders which take patients to general hospitals. Most readers will probably be astonished to learn that during the year 1933 for every one hundred patients admitted there were forty-six discharged, of which number thirty-nine were considered recovered or improved. Of those discharged 22 per cent. had been hospitalized for two months or less, 55 per cent. for less than six months, 74 per cent. for less than one year, and 87 per

cent. for less than two years. Furthermore, it has been found that at the end of ten years over one half of the patients discharged are living in the community, a small proportion of them, to be sure, having had in the interval one or more readmissions to mental hospitals.

It should be understood that mental disease is not a unitary thing; there are many different types, some of which occur early in life, some in middle age and some in advanced years. The discharge rate and the prospects for these various types are not all alike by any means. This is true likewise of the symptomatology. The average citizen probably thinks of the mentally disordered person in the terms of a "raving maniac," one who is disturbed, noisy, disheveled, annoying others, possibly even making homicidal attacks, and so on. As a matter of fact, patients of this type constitute perhaps not over 5 per cent. of the population of a mental hospital. Some patients are depressed, some are confused, some are apathetic, many show relatively little disorder of conduct. Some of this difficulty is perhaps due to the legalistic notion that a person is either sane or insane, and to the rather fixed definitions, most of them entirely out of line with psychiatric thought, which the law gives for that legal term "insanity." Mental disorder represents a failure of the individual to adjust to his environment, but such adjustment depends on many things: it depends upon his heredity and the constitution with which he was born, on his training, on the functioning of his ductless glands, on the situation with which he is confronted, his education, his native endowment and many other factors. In some instances we have degenerative processes due to old age, in others we have brain disease due to infection or intoxication, and it is quite obvious that with so many varying factors the types of reaction and the manner in which adjustment fails will vary. Mental disorder is not necessarily accompanied by disease of the brain, although brain damage often produces mental symptoms. It is rather a failure of adjustment of the entire personality. "Mind" is not a unit, but rather an abstraction which symbolizes the sum total of the reactions of the individual at the social level.

A few words may be in order concerning some of the broader general types of mental disorder which find their way into hospitals. One of the important groups is that due to degenerative processes, that is, hardening of the arteries of the brain (cerebral arteriosclerosis) and senility. By the very nature of the disorder, the outlook is poor. Together these types make up about 18 per cent. of the admissions to mental hospitals. As for the future, a factor which can not be overlooked is the changing composition of the age groups in the population. Human life is lengthening, the birth rate is falling, immigration has almost ceased. Furthermore, the incidence of mental disease increases steadily as age advances; the rates of mental disorder for the respective age groups of the population are somewhat more than four times at age 80 what they were at age 20. Whereas in 1900 only 4 per cent. of the population was over 65, at present 6 per cent. is over 65, and it is estimated that by 1980 somewhere between 14 and 16 per cent. of the population will be over 65.[2] In other words, there is every reason to believe that the number of patients in mental hospitals suffering from cerebral arteriosclerosis and from senile psychoses will probably increase rather materially as time goes on. It is difficult

[2] "Problems of a Changing Population," National Resources Committee, p. 25. Washington, 1938.

to see how very much can be done about this.

There is another group due to the infections, of which general paresis is a conspicuous example. This disorder is one of the late results of syphilitic infection, and until about twenty years ago was considered to be a rather promptly fatal disorder once it had reached the stage of calling for hospital care. During the world war considerable impetus was given to the campaign against syphilis, and the campaign has been carried on since, having been given more recently a very strong reenforcement through the splendid efforts of Surgeon General Thomas Parran and the symposium organized and presented by the American Association for the Advancement of Science. Already the effects of the twenty-year-old campaign are being realized in a fall in the admission rate of general paresis; it is confidently to be expected that as time goes on the rate will fall still further. Furthermore, since very striking advances have been made in the treatment of this disease through the fever therapy devised by Wagner-Jauregg, the prospects of this group, which now constitutes about 9 per cent. of first admissions, are good.

As an example of another group of mental disorders we may mention that due to intoxications; the alcoholic psychoses are a type. Although a drop in admissions for this type of disorder began about 1914, apparently as the result of the campaign against the excessive use of alcohol, and although there was a sudden drop in 1920 when prohibition went into effect, there has been a rather gradual rise since 1920, with the result that we are approaching the pre-war levels in the admissions of alcoholic psychoses, now about 5 per cent. The educational program against alcohol was badly disrupted by prohibition, and it will take a number of years to make this effective again. Ultimately some drop in the rate of alcoholic psychoses is perhaps to be expected. Mental disorders due to other drugs, such as opium, cocaine and marihuana, are relatively negligible. Admissions due to head injuries are rather infrequent; although mental disorders sometimes ensue following head injury, they are generally not sufficiently disturbing to call for commitment to mental hospitals.

There are some types of mental disorder which have no uniform and clearly demonstrable organic bases. They are, perhaps, constitutional in predisposition and environmental as far as precipitating factors are concerned. With the group of depressions, which account for about 12 per cent. of first admissions, some progress has been made with "shock therapy" in recent months. These depressions are rather inclined to spontaneous recovery and usually do not call for a long hospital residence, except for that relatively small group which occurs during the involutional period and in which the duration is somewhat longer and the prognosis somewhat less favorable. Another large group and very important one is that of dementia praecox, or, as it is frequently termed, schizophrenia. On account of the relatively early age at which this tends to develop and the rather long course which it is inclined to run, nearly one half of the population of any mental hospital is found to be suffering from this disorder, although the first admission rate is only about 20 per cent. Much research work is being carried on in the field of schizophrenia, and a little progress has been made recently through the so-called "shock" treatment. Many baffling problems are still presented, however, and the future is not entirely clear. It is felt by those experienced in this field that much

depends upon preventive activities, which will be touched upon later.

The question is often asked whether mental disorder is increasing. The warning should be given that the only reliable statistics are those of *hospitalized* mental patients. We have very inadequate means of knowing how many cases of mental disorder there are in the community. Consequently, if a state provides inadequate facilities and makes it extremely difficult to enter a hospital, it may boast of a low mental hospital rate. If, on the other hand, it is progressive, as New York State is, providing ample facilities, a large proportion of those in need of care will receive it. The discrepancy among the several states in the rate (per 100,000 general population) of the patients hospitalized is enormous, the figures for New York and Alabama being respectively 464.5 and 163.5. It may be said very briefly that there appears to be a slight general rise in the admissions to mental hospitals, and a slight increase, rather steady, in the population of these hospitals. It is questionable whether at the present time, at least, the prospect is alarming. The figures which have been given for the trend in the senile and arteriosclerotic groups, however, certainly seem to indicate heavier future demands for mental hospital facilities.

Much used to be said about the influence of heredity in mental disorder. That there is such a thing as heredity can not be denied, but it is not looked upon to-day as one of those inescapable things to which one may as well surrender without a struggle. The growth of the mental hygiene movement has laid stress upon the importance of attempting by proper training, guidance and environment to overcome native handicaps, and much can be done in that line. As for environment, it is quite likely that the constantly increasing pace of life has no particularly beneficial effect upon the mental hygiene of the public; on the other hand, it can not be proved to be the principal factor in any increase in mental disorder. The old myth about farmers' wives, who were generally reputed to be particularly susceptible to mental disorder, has long since been exploded, and it has been found that the rates for hospitalization are in general slightly higher in urban than in rural communities. This, however, may be due in large measure to the fact that peculiarities of conduct are much less well tolerated in closely settled areas than they are in rural districts, with an increasing likelihood of commitment.

The modern mental hospital is as far different from the old asylum as could well be imagined. It is a general hospital thoroughly well equipped, surgically and medically, to deal with any physical disorders which may arise among its patients. It is equipped in addition with occupational therapy, with hydrotherapy and other specialized forms of treatment designed to remedy the disordered mental attitude of the individual. Padded cells have not existed for many years, and seclusion and restraint have long since been virtually abandoned, having been found to have a deleterious effect on patients. As much freedom as possible is given to patients, and the atmosphere of the hospital is one as nearly approaching normal community life as can well be secured in an institution. There are various types of entertainment and social activities, all designed for the purpose of helping the patient to readjust himself to mingling with his fellows in a normal way. Recently considerable attention has been given, partly for economic reasons, to the possibility of caring for the mentally ill in families after the more acute problems have been dealt with in the hospital. The

system of family care, which was first introduced into Massachusetts in 1885, has at last been adopted by several other states.

It should not be thought, however, that all mental hospitals are the ideal places that have been described. Unfortunately some states have been decidedly backward in their care of the mentally ill, have been niggardly in the appropriations voted, and have allowed partisan spoils politics to interfere with efficiency and with the securing of adequately trained and interested personnel. It is to be hoped that the new interest in public health now being fostered by the Federal Government will bring about improvement in those states in which it is needed. Mental hospitals, in addition to their intramural activities, are engaging constantly more and more in community activities, particularly with relation to child guidance and adult mental hygiene clinics. These activities are extremely important from the preventive point of view, being designed in the case of children to overcome habit difficulties, and in the case of adults to prevent mental breakdowns in those who appear to be showing symptoms of incipient difficulty. Mental hospitals, or at least the more progressive ones, are centers of research and of teaching—a trend which is rapidly developing.

Even the most vigorous opponents of "state medicine" have always admitted that the care of the mentally ill is a proper function of government. As the public becomes more acutely aware of the true importance of mental disease in the community and of the needs of hospitals administering to this group, we may look to see the standards raised and greater efficiency brought about in the humane care and treatment of the mentally disordered.

THE CURSE OF ANGKOR

DEATH COMES QUICKLY IN THE TROPICS

By Dr. ALFRED C. REED

PROFESSOR OF TROPICAL MEDICINE, UNIVERSITY OF CALIFORNIA

We have a long journey before us, across many thousands of miles and many hundred of years. We stand on the muddy black bank of the Great River, the Mekong, 2,000 years ago. A shadowy figure squats before us looking at some yellow grain in his hand. He is Dak of the Jungle, and he is here because of a dream in which My Lord, the King of the Cobras, ruler and owner of the land, directed him to leave his thatched hut, high on stilts above the jungle floor, and go to the Great River, where a new magic would be revealed to him. As he looks stupidly at the grain in his hand, a second figure stands beside him, a dark, lean, tall man in outlandish garments. The stranger asks Dak about what he is looking at, and Dak patiently tells of the dream and the useless grains that he finds in his hand.

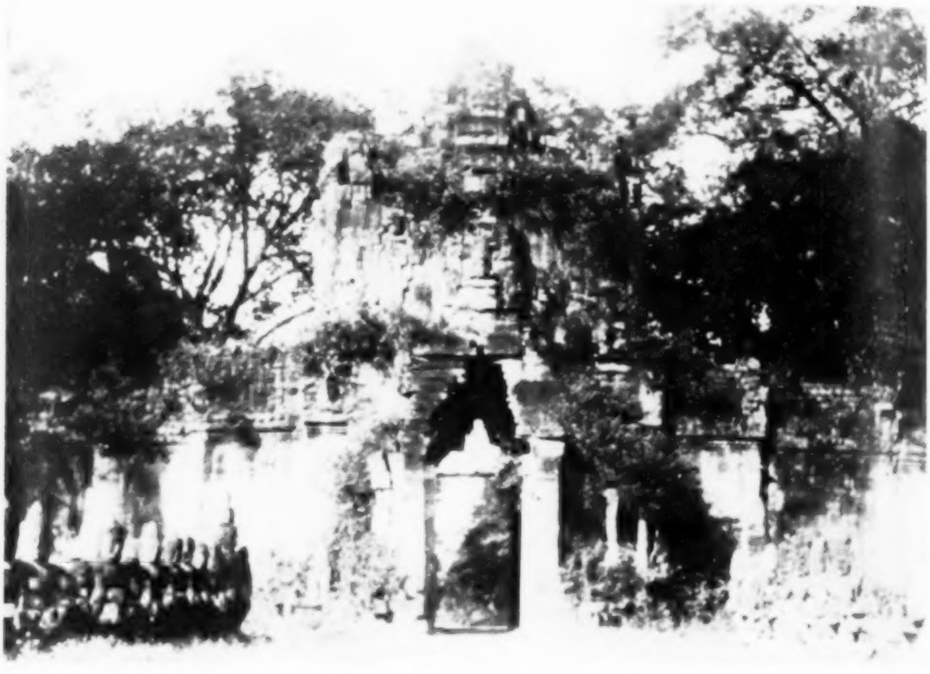
The newcomer is Prince Cambu (Chandu) from the land of Arya Deca (the Deccan of India), driven out from his ancestral home by long drouth. His wife, Mera, the foster daughter of Siva, had died, and his people were destroyed. He paid close heed to Dak's story, looked sharply at the yellow grains Dak was about to throw away and saw a vision of a new race in the fertile valley of the Mekong, raised up for the glory and worship of the gods, through this magic talisman, Rice. His vision saw the jungle pushed back to the further hills and replaced by solid fields of rice, than which no other crop can feed more mouths, saw cities and villages, a great and powerful empire, and turned with Dak to seek out the Cobra King for permission to establish himself in the land. He married the King's daughter, the serpent princess, who, being immortal, took on her the lovely form of a beautiful woman. And so, as runs the ancient story, the Khmers came into the land from India, replaced the jungle with its chiefest enemy, rice, and grew into a mighty nation. And the Sons of Cambu, the Camboga, gave their name to the land of Cambu, Cambodia.

History dimly records the steps of the old folk myth. In the centuries preceding the Christian era, a stream of immigrants from India came into the delta regions of the Mekong and the Menam. By the fifth century, A.D., the Khmer race was established in these lower valleys and was beginning to spread northward. In the thirteenth century it reached its greatest glory. At the end of the ninth century, Yasovarman, the thirteenth king of the serpent dynasty, built the new capital city of Angkor. He was the Leper King, referred to in the sculptured rocks and from whom the terrace of the Leper King to-day derives its name. Ankor Wat was built a century later. Its roots were in Brahma and the Sanskrit language. It drew increasingly from the arts of China. It is the race of half-hidden mystery that left as its sole monument the remarkable ruins of Cambodia.

But to return to the legend, where truth is always being rediscovered as it is released from the cerements of allegory and symbolism. The serpent princess, who became the wife of Cambu, was immortal and ageless, Cambu fulfilled his years and his place was taken by another, but the queen was young and fair as ever. It became her custom to espouse each succeeding king, as only thus could

MAP OF SOUTH CHINA SEA

WITH SIAM, INDO-CHINA, HONGKONG, MANILA AND SINGAPORE.



CHIEF GATE ANGKOR THOM
REMNANTS OF BUDDHA-LIKE GIANTS IN STONE AT SACRED NAGA.

she watch over the Khmers who were her children and whose land was her father's. She returned to her cobra-form by day and only at night appeared to the king as his first wife, whom he must visit each evening before he saw any of his other wives. Thus through the story of the Khmers runs the dark and elemental cult of the snake.

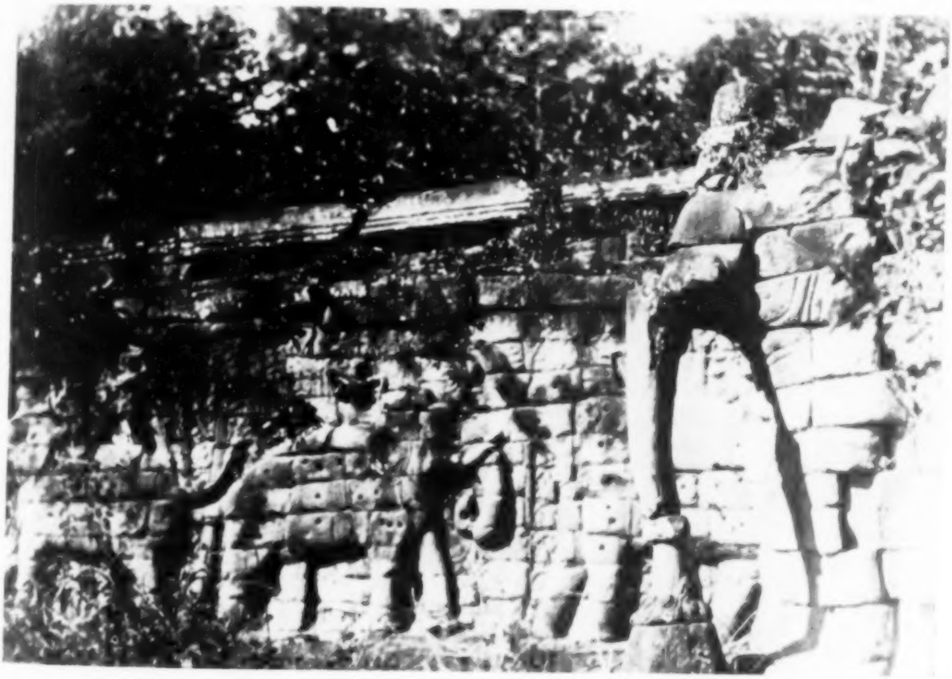
At this very point we must pause to note the significant fact that in all the monuments and ruins of Cambodia the serpent, the cobra, the Sacred Naga, plays a prominent part. Not only do the folklore and mythology of Cambodia go back to an original ownership of the land by the Naga, but the very fact of this ownership and recognition in story points to still older origins. The oldest of these is found in Hinduism, which is based on the supporting power of the primeval cobra, from which was derived this earth and its inhabitants. Serpent worship runs like a dark thread through all the mazes of Hindu literature and belief from the earliest to the latest. When Buddhism raised its head from the fold of Hinduism, the Sacred Naga again became active, and we find the Naga supporting and sheltering Buddha at the time of his enlightenment, so that the seven-hooded head of the cobra becomes one of the symbols of Buddhism. Thus in Angkor, we see the cobra, first the faithful servant of Siva, then of Buddha, and finally of the new culture on the banks of the Mekong.

Similar to the spread of the cult of the snake to Cambodia, was its spread from Hindustan to Egypt. Miss Helen Gordon Barker (personal communication) states that, in the Egyptian hieroglyphics, the cobra occurs constantly with body erect and hood expanded. Its name "ouro" signifies "king." It is also in this position on the headgear of

the pharaohs of ancient Egypt and on the head of Tutankhamen in the temple of Luxor (fourteenth century, B.C.). Miss Barker quotes R. P. Knight ("Symbolic Language of Ancient Mythology," 1876) as follows: "The sort of serpent most commonly employed by Egyptians, Phoenicians and Hindus is the Cobra di Capella, naga, or hooded snake. It is the hooded snake, which we believe to be a native of India, from whom Egyptians and Phoenicians borrowed it and passed it on to the Greeks and Romans."

The "Encyclopedia of Religion and Ethics," edited by James Hastings (1912), says: "The Cobra serpent was much reverenced in prehistoric times, when it appears as a house amulet to hang up, or as a necklace amulet, or coiled round a stick, or in pairs twisted together. The cobra with expanded hood became the emblem of judgment and death, and appears on the cornice of the judgment hall and on the royal headdress." The hooded snake, the Cobra di Capella or naja, is found up to an 8,000 foot elevation all over India from Ceylon to the Himalayas. The closely allied naja haje is found over a large part of Africa and, according to the Encyclopedia Britannica, it was the asp of the Egyptian divinities.

The story of the cobra of Angkor thus is related to the story and meaning of the medical caduceus and the symbolism of the serpent in Greek, Roman and Phoenician philosophies. The serpent as a symbol is world-wide. The Hopi snake-dance, African juju and the Voodoo worship of Haiti, the serpent in the garden of Eden and the plumed Mayan serpent of ancient Mexico have origins and meanings probably all dating back to the sacred naja of India. And back



ELEPHANT TERRACE IN ANGKOR THOM

A REVIEWING STAND FROM WHICH NOBILITY LOOKED DOWN ON ANIMAL SHOWS AND MILITARY SPECTACLES.

HEADS OF COLOSSI
IMMORTAL GUARDS ON THE AVENUES APPROACHING THE CITY GATES.

of that lies the cult of the snake, old as man himself, and derived from the matriarchal society which beheld in the snake the symbol of the male influence. In it was joined the knowledge of good and evil which alone gave eternal life.

The story of the snake, therefore, gives a strong clue to the origin of the people who settled the ancient valley of the Mekong. Their first origins must have been in India in Hinduism, and later this must have been overlaid by Buddhist culture from the north, from either China or Tibet directly. At the time of their destruction, their temples contained only one great figure and no other images, indicating that Hinayana Buddhism then as now reigned in the land.

Aside from the incompletely deciphered carvings of the ruins, our chief and, in fact, almost sole source of information of this ancient kingdom is from the diary kept by a Chinese traveler, Chow Ta-quan, who visited Angkor and lived there for some time about 1296 A.D. At this time the country was at the height of its power and glory. The great city itself, inhabited by a million or more people, was the center of a populous plain, in which cities were scattered about through the rice fields. The forest and jungle were driven back, the timber being used for construction of the common houses of the common people, and for scaffolding necessary for the erection in masonry of the great temples and houses of the nobility, whose ruins stand to-day.

The old Chinese traveler said that no saws were used in construction, but only hatchets, all wooden beams being hewed out from the tree trunks. East and west of the city itself were two great tanks or reservoirs, filled from the same stream which now flows past Angkor Wat and down through the village of Siem Reap.

These great reservoirs are now covered with paddy fields, and the jungle surrounds them. In the city itself the tall temple towers bore flagstaffs, with streaming banners and pennants, and the city itself was magnificently decorated with gold, presenting a spectacle of wonder to the travelers and wandering tribes of the vicinity.

The wide extent of cultivated fields was necessary to support the large population, as well as being a direct result of forest clearance to secure timber. It is a striking fact that in the buildings of a permanent nature stone was brought for vast distances and used by the methods of the wood builder and not the methods of the masonry worker. It is apparent that the construction ability of the people was originally that of handicraft in wood. When they turned their attention to stone construction no new principles were developed, but the old methods were used, resulting in no use of the mason's art and in architectural features which will be mentioned later.

In their general style there was some suggestion of the architecture of ancient Egypt. The Egyptian pylon can be seen by the imaginative eye in the lack of the use of a keystone or true arch by the Cambodians. The weight of the superstructure was supported on a lintel by walls which sloped outward almost to the extent of external buttresses. In these side walls the stones were overlapped inward more and more until finally they were crossed by a long stone at the top. In fact, the entire use of the stone suggests that these people originally were woodworkers and applied to their stone constructions the principles they had already learned in wood.

Chow Ta-quan looked with admiration at the lavish use of gold for decoration, apparently in the same fashion that it is seen to-day in Japan, Siam, Burma and elsewhere. Angkor had two golden

DOORWAY SHOWING LACK OF ARCH CONSTRUCTION
NOTE ALSO EARTHQUAKE DAMAGE.

DETAIL OF CARVINGS IN ANGKOR.

towers, a golden bridge, golden window frames in the council chamber of the king and a special golden audience window in which the king sat. The dwellings of the nobility and of priests faced east. In the palace itself was a golden tower in which the king slept. Here the spirit of a nine-headed cobra lived, and in it was vested the absolute ownership of the kingdom. This cobra appeared to the king every night as a woman, and the king's death was foretokened by the non-appearance of the cobra on any night. He described the king's dress as including a golden crown, which was a high pointed diadem similar to those of the dancing girls depicted in the stone carvings. Garlands of jasmine and other flowers were worn, and on his neck nearly three pounds of pearls, besides bracelets and golden rings. The soles of his feet were bare and, like the palms, were stained red. Then, as now, it was customary for the noble ladies to stain their palms and soles red, although the soles of the feet were invariably concealed from sight as a matter of decency. The king was the only man who had a similar privilege.

Our reporter states that the king had five wives, one a chief wife, and the others representing the four points of the compass. He had heard tell also of there being three to five thousand concubines. With customary racial prudence, Chow Ta-quan looked askance at the excessive bathing habits of the Cambodians. "The people often are ill. Their too frequent bathing and excessive washing of the head has much to do with this. Often they recover unaided. Many lepers take up their position on the road, but, though they live and eat with them, people do not catch this illness. They say it is a disease they are accustomed to in the country. Once there was a king who caught it, but he was not scorned for that. In my humble opinion it is excesses in love and abuse of baths that bring on this illness." "They have no coffins for their dead but only matting. They cover them with a sheet. When they get far outside of town to some uninhabited place they leave them there. The rest was for dogs and vultures. Some were already beginning to burn their dead. These latter were all descendants from Chinese." It might be added that this is still the customary method of disposing of the dead in Chinese Turkestan and elsewhere in Central Asia, whence the custom probably came to Cambodia.

Chow Ta-quan deplored the number of Chinese at Angkor, because it decreased their prestige. The Cambodian populace he thought very simple because of the respectful fear they showed the Chinese, prostrating themselves to earth before them and calling them Fo (Buddha). Miss Wheatcroft, in her book, "Siam and Cambodia," gives much description from this old traveler and other sources about the ancient kingdom of the Khmers. Her volume is decidedly worthy of perusal, and acknowledgment is made for the reports used here, especially from the old Chinese traveler.

Outside Angkor City is the great temple of Ta Prohm. Here Miss Wheatcroft describes the stele which lists the temple dependents in the days of its glory. There were altogether 79,265 persons attached to Ta Prohm alone, of whom 12,640 lived within the temple enclosure. There were 18 officiating priests, 2,740 secondary priests, 2,232 assistants, including 615 women dancers. Within the temple confines there must have been streets of wooden and bamboo houses, such as are seen to-day in the adjoining village, Siem Reap. There are also records of well-organized hospitals on the temple grounds with doctors, nurses and assistants, both men and women. Part of their duties consisted of the care of the aged and sick among the pilgrims and worshippers. One record states that 102 hospitals were in operation in Cambodia in the year 1186.

In our day Cambodia fascinates the traveler with its monuments of past greatness. Let us look at it under the prosaic sun of the twentieth century.

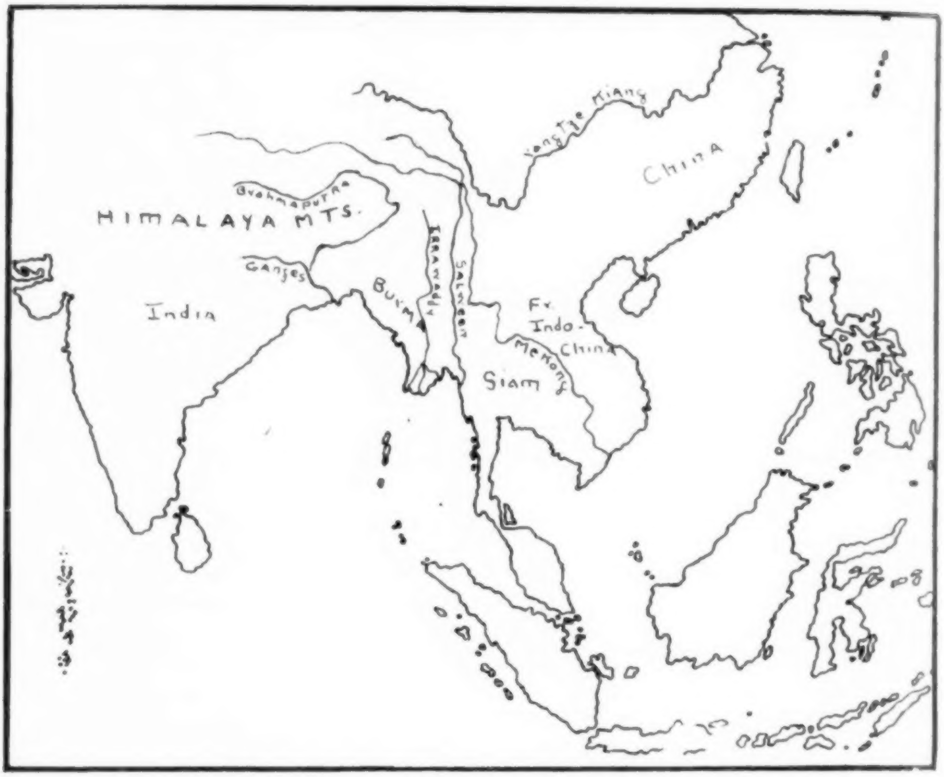
Close around the eastern end of the Himalayas sweep five torrential rivers. They drain Tibet and bring down a turbulent flood of life-giving water and silt from those ancient mountains which look down upon the earliest home of mankind and of human culture. Not only do these five great rivers bring silt and moisture to the receptive earth of the southland, but also there flows down from the same high table land a stream of myth and ancient folk ways, whose influence has spread in the past throughout the low countries of southeastern Asia, across the great islands, into Australia and out over the Pacific almost to the New World.

Nearest of these five rivers to the height of the Himalayas flows the great Brahmaputra, which curves back on to the plains of India and touches the delta of the Ganges. The angle between the Brahmaputra and the Salween is filled by the basin of the Irrawaddy flowing down serenely through its jungles, past Mandalay and the Shwee Dagon pagoda of Rangoon. Close to it to the east comes also from Tibet the mighty Salween, signalized to English-speaking readers by the Moulmein Pagoda near its mouth. These last are the rivers of Buddha, as the Brahmaputra is the river of Siva and Hinduism. Of the five great rivers, the two easternmost flow together to form the Father of Waters, the Yangtse Kiang of China. Here Buddhism also, like a flood, has overwhelmed the land and spread on in militant form into Japan. In between these two great courses of influence and culture and physical power, we find, curving also around the easternmost end of the great mountains, the River Mekong, which takes a more southerly path and carries the same things from Tibet to the great plains of Siam and Indo-China.

The lower valley of the Mekong curves around toward Saigon on the lower China Sea. It lies between Siam on the north and west, and the great French province of Annam on the east. It ex-

PRIMITIVE CAMBODIANS OF TO-DAY

THE BABY CONTINUED TO SUCKLE WHILE THE MOTHER FOLLOWED THE TRAIL CUT BY THE MURDEROUS KNIFE OF THE BOY.



THE FIVE GREAT RIVERS OF SOUTH-EASTERN ASIA.

tends down to the Gulf of Bangkok and the lower country of Cochin China. Its capital is Pnom-Penh, as it has been for a millennium or more. It is called Cambodia.

French Indo-China lies in a most strategic relation to the Pacific Ocean and to Asia. Its capital and mighty fortress of Saigon lies equidistant from Hongkong and Manila, by nine hundred and fifty miles, while Singapore is six hundred and fifty miles to the south. Facing the Philippines across the China Sea, Saigon and the richness of Indo-China lie, as it were, between the great jaws of the British Lion at Hongkong and Singapore. Because of this, the jaws can never close and politics must constantly charge the atmosphere.

Cambodia is to-day as flat and floorlike as during the millennia of its past history. The river Mekong winds in long undulations through it, and in flood spreads out broadly over its territory. In ancient days it was a rice-raising and rice-eating country, therefore, a country of enormous population. In present days the population is low, indeed, but rice culture is returning and the jungle, which has intervened for six hundred years, is rapidly being pushed back.

The visitor to Angkor may start from Saigon by motor car, going to Tayninh on the Pnom-Penh road, and then turning north over good roads to reach the Mekong River at Kampong Cham for the ferry. Across the river, one soon joins the high road from Pnom-Penh north to Angkor. From Saigon this journey can easily be made in one day. By special arrangement it is now possible to fly from Saigon to Angkor, but who wants to fly over Annam and Cambodia?

The alternative route is from Bang-

kok. The wheezy little train leaves Bangkok at 7 A.M., reaching the Siamese border station of Aranya Prades at 4 P.M. For five hours the country is flat as a floor, little above sea-level and devoted to rice culture. Paddy fields, marshes and canals cover the landscape. Sampans and canoes go everywhere between the fields. The little train stops at the slightest provocation. The engines, as all over Siam, burn wood in place of coal or oil, which are not found in the country. Every station has long platforms piled high with endless cut wood which coolies noisily load on to the tender. Showers of sparks and charcoal pour from the engines.

Water buffalo adorn the countryside in great numbers, attended by numerous small white herons, especially when grazing or lying in water holes. It is a drab and uninteresting journey. At noon one enters a different terrain. Tall, white, sepulchral trees are interspersed with bamboo thickets and patches of jungle. Low hills and rolling plain become largely devoid of cultivation. There is always a good breeze, which still allows clouds of mosquitoes to invade the car. Siam is oppressed by mosquitoes and poor sanitation in spite of the glowing disclaimers of its native sons.

Aranya Prades is four miles from the frontier and in the last open country before the jungle, which stretches northward to the mountains and China and eastward to the China Sea. A small rest house provides clean and comfortable rooms and American coffee, always a thing to be devoutly wished for in French and British lands. Aranya Prades is left behind at 7 A.M. by auto-

CAMBODIA AND THE ANGKOR DISTRICT.

A ROYAL CORNER SHOWING DOOR CONSTRUCTION.

mobile. The French border station of Poipet marks the entrance into Cambodia. At low water, Angkor is four hours distant around the northwest end of the Tonlé Sap, which is a great fresh-water lake, attached to the Mekong River like the gall-bladder to the bile duct. At high water, however, one follows a rough, hard, metalled road 280 miles southeasterly to the Cambodian capital at Pnom-Penh. These French roads are excellent in their engineering and furnish the only means of communication, except by water. They are roughly surfaced and the available French cars seem quite devoid of springs and ride on small high-pressure tires, making an ensemble which is hard on disposition but doubtless an excellent tonic for the liver.

This country of western Cambodia is the home of the white rhinoceros, the cobra and various other death-dealing beasts. For the first half day it is open, with patches of rice fields, clusters of trees, but mostly dry, barren upland, flat to the horizon. Half way to Pnom-Penh, patches of jungle begin, occasional hills, many rivers and small streams, more and more palms, and gradually a scattered forest in places dense and attractive. In general, one does not care to repeat the journey for scenic effects.

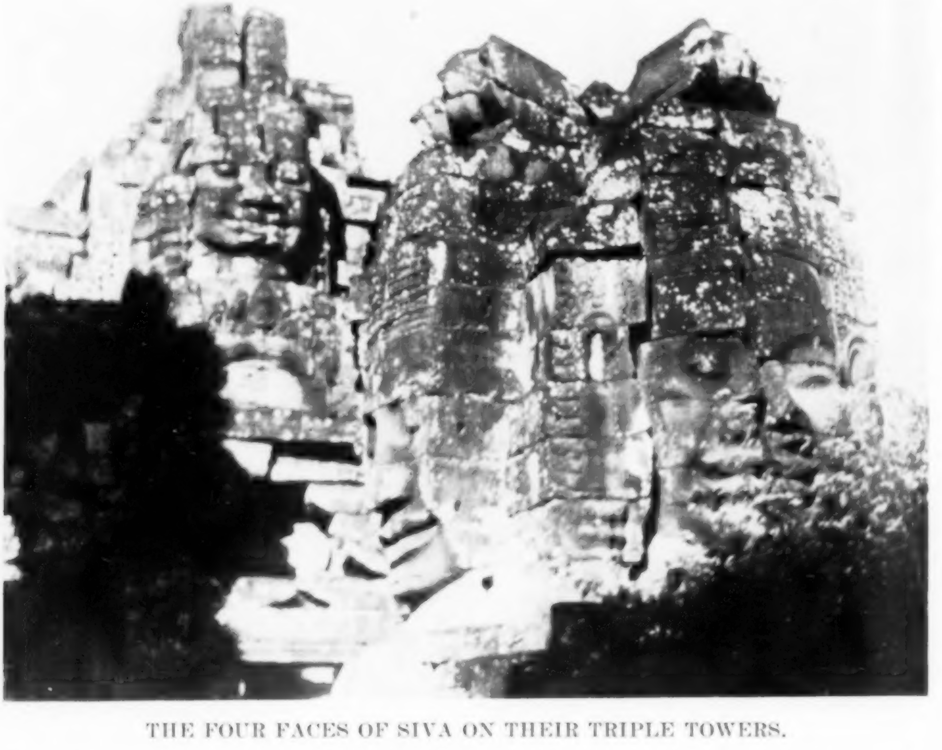
Pnom-Penh is a dirty, cluttered French colonial town with a fascinating past and a tawdry present. Except for the Cambodian Museum, one can omit it without loss and with much mitigation of discomfort and poor food.

Leaving Pnom-Penh at 6 A.M., the road overlooks the great Mekong River from a broad dike along which is a succession of villages, set in dense tropical forest and shrubbery. After 20 miles, the Mekong is crossed on a weird flat-

boat, ferried the half mile across by an asthmatic launch. At ten o'clock Kampong Thom is reached, where is a good rest house with fit food to refresh the traveler and wine to make light his heart. But by carrying crackers and bottled water, no stop is necessary, and after all, one does not really want to stop just three hours from Angkor. The landscape for the entire two hundred miles is flat as a table, spreading over the rich alluvial valley of the Mekong. The bird life is remarkable. Thousands of herons, secretary birds, cranes, pelicans, kites and crows rise in swarms ahead of the car, wheel lazily about and settle back to their duties of commissary and meditation. Brilliant colors are matched by grotesque shapes. Flamingoes live westerly toward the Tonlé Sap.

Rice growing gradually gives way to jungle and forest. Water increases. Monkeys abound and the trees re-echo their speech. The countryside becomes a rich jungle with interspersed rivers, and clearings set with paddy fields and villages. The vegetable mass of the jungle is 20 to 30 feet deep, above which towers a glorious forest, chiefly of hardwoods, including teak and mahogany. In overgrown clearings are tangled masses of bananas and palms. The slender, graceful areca palms are unusually tall. Bamboo grows in thickets and clumps. This remarkable tropical plant, together with palms and mangroves are most characteristic of the tropics, and, like the palm, the bamboo is most vital for man's life there. Alfred Russell Wallace defined the tropics as those lands where the palm is indigenous. Its hundred and twenty-five varieties serve man in nearly every one of his needs. They provide food, raiment, protection, building material, condiment, intoxicating beverage, stimulating drug and

A COURT IN ANGKOR WAT.



THE FOUR FACES OF SIVA ON THEIR TRIPLE TOWERS.

many other requirements. The same is true of the bamboo. The uses are unnumbered. Its mere beauty justifies its life. Practically every human need from food and shelter, to weapons, pumps and storage receptacles, is met from this remarkable plant.

Cambodian villages are built chiefly set high on stakes or piles to keep the houses above flood level. The house itself has a low roof of nipa thatch, small windows and a floor of slender poles or bamboo. A village resembles a cluster of bird houses.

The road skirts the small town of Siem Reap and three miles further on the three great towers of Angkor Wat suddenly leap above the level sea of forest. Just across the great moat from the temple is the pleasant and comfortable Hotel des Ruines, strung out in low buildings connected by covered passageways. Some two miles to the north lie the remains of Angkor Thom, the capital of the Khmers. Well over a mile square, the ancient wall stands to-day enclosing palaces and temples, whose stones have been laid back under expert direction so that the great city can be visualized in its resurrection from the living tomb of the jungle. Whether one sees the silent and implacable ferocity of the jungle, or whether one sees the buoyant life and fertility, makes the difference between a green hell and an opulent home for man's future. The difference lies exactly in the strength and availability of the master hand of scientific medicine which alone bends the tropics to the support, comfort and progress of mankind.

Six hundred years are shed with the jungle itself, as the French archeologists have literally exhumed these ruins from their green death and one sees the an-

cient glory of the place with the remarkable fact that no funerary relics are found. Straight clean roads traverse the fifteen-mile square in which lies Angkor and its outlying temples. Outside the city, roads lead past stone squares, some covering forty to sixty acres, and not yet released from the jungle grip. These are buried in deep, dark forest, with projecting and alluring angles and corners of temples, shrines, pools, gardens and beautiful rock carvings.

As sunset nears, a sudden deafening chime, like myriads of electric bells, sounds the evening anthem of the cicadas which swarm through the trees. The hum and buzzing of a general insect chorus are set off against the croaking and deep booming of multitudinous frogs. The chattering of monkeys and the clear, mellow calls of the geckos complete the orchestral vespers. With the darkness comes complete silence.

Across from the hotel terrace stand several elephants, at the service of strong-jointed travelers, while against the darkening eastern sky rise the dull brown towers of the great wat, behind the dark waters of the sacred tank. Yes, it is magnificent. It is overwhelming. It oppresses. It cries aloud of another world, and the ghosts of the past are almost visible. In fact, they are entirely visible. A straggling torch-light procession comes with the darkness. Odorous resins and balsams have been collected by the village children and bound into bark torches. The wavering light and the incense smoke lead one in silent fascination to follow the procession across the great elephant causeway, where the torches are reflected from the portentous waters of the tank, over to the massive façade of the wat, silhouetted against a star-lit sky paling in faint moonlight.

The torches make a semicircle of footlights. The music of ancient Angkor comes from the orchestra of tom-toms

PRESENT-DAY CAMBODIAN HUT,
PROBABLY SIMILAR TO THE COMMON HOUSES OF ANGKOR.

AN ISOLATED SHRINE
IT STILL RESISTS EARTHQUAKE AND JUNGLE.

and wooden drums, with a quaint and very sweet flute and wooden notes like a zither. Verily the pipe of Krishna played there before the old temple walls, to breathe once more the air of man and dance once more to the glory of Siva.

The girls were dressed elaborately in rich satin costumes and tall headgear, barefooted with heavy silver anklets. One man took part in mask. Wonderfully graceful children added their part. The Cambodian dances are slow and graceful, consisting mainly of posturing, bending and stately pacing. The use of the hands and arms is expressive to an unbelievable degree. All is symbolic and narrative, meanings largely lost in the dim mists of tribal memories coming down to the present villagers. Such a scene is not soon forgotten, the stage setting of temples and sky, the incense torches, the grotesque and bizarre dancing, the weird and poignant music and the Cambodian faces roundabout intently watching. It is easy for the imagination to drift to other days of Siva and Buddha, and a world vastly younger and immeasurably wiser in the lore of the spirit.

To visit Angkor is to be overwhelmed with the tremendous extent of the ruins, their remarkable preservation in spite of jungle, earthquake and weather, their somber and compelling beauty, and the exquisite perfection of the innumerable miles of rock carvings. The distances are great, and the dangerous Cambodian sun makes it necessary to ride between them. The houses of the common people have disappeared. Great forest trees and penetrating roots and creepers have made havoc. The footprints of earthquake are visible, but enough remains of massive masonry and great piles of structure to show the magnificence and extent of the originals.

GIANT DIPTOCARPUS
IT GROWS ON TOP OF AN EXQUISITE STONE SHRINE ENTWINED BETWEEN ITS MASSIVE AIR ROOTS.

OLD GATE SUPPORTS FOREST GIANT
ITS HUGE AIR ROOTS STRETCH FROM THE OLD ENTRANCE GATE ACROSS LONG STONE PAVEMENTS TO FIND SOIL.

One example may be detailed. From the auto road at one place a narrow path leads a quarter mile, winding among 200-foot trees, 6 to 10 feet in diameter, growing out of an impenetrable tangle of smaller trees, vines, creepers, brilliant flowers and undergrowth. Suddenly high rock ruins appear across an ancient stone causeway, which leads over a tank now dry and overgrown. At the end of the causeway one penetrates through an entrance tower or pagoda, and then a narrow, dark gateway through a carved stone wall into the temple itself. It is totally invisible from a distance of fifty yards. The temple towers a hundred feet high, the solid masonry covered with a heavy growth of trees, vines, creepers and shrubs. Monkeys howl and chatter on every side. Within the temple are many long corridors of cells where the priests lived. These all radiate from a central high stone tower in which is the image of a reclining Buddha. All the walls are frescoed with bas-reliefs, in which the figure of Buddha appears over and over again. Many inner courts are beautifully shaded by giant trees. Most of the great pile has not been cleared sufficiently to permit access, but enough is in evidence to fill the spectator with awesome wonder at the architectural ability and the art of those old builders.

In front and overlying the temple itself were two gigantic diptocarpus or fromager trees, whose enormous roots, six to ten feet in diameter, crawl like prehistoric pythons across hundreds of feet of masonry pavement, until finally they find access to the soil. In the rock carvings here, as all through the Angkor district, lies a rich commentary on the history, culture and customs of the Khmers.

A visit to Angkor is incomplete with-

DIPTOCARPUS AND SHRINE
AN EXQUISITE COMBINATION OF LIVING DEATH AND DYING LIFE.

PUSHING BACK THE JUNGLE

NATIVES SAVE THE RUINS FROM A GREEN DEATH AND RESTORE STONES TO THEIR ORIGINAL PLACES.

out climbing the high central tower of the great wat and from the topmost terrace watching the sun sink into the green-black sea of the jungle. Gradually only the western sky is alight, and the spirits seem to walk again in the courts and colonnades of the huge sanctuary at one's feet which gradually sinks back into the oblivion which has buried it for 600 years. A few Buddhist monks have crude quarters in one court. Otherwise only the innumerable bats are bestirring themselves in countless millions, preparing for the night's work. Their twittering and stench are almost overpowering in the dark corridors and halls. Perhaps they are in reality the manifest stirrings of those evil forces which conquered Angkor and which, even yet, keep so much of the tropic world in bondage.

One leaves Angkor in the freshness of the morning for the return to more prosaic things. Three hours bring Kampong Thom, with its clean rest house and a substantial lunch. Then the new road turns off to Kampong Cham and the breathless work of ferrying the car across the broad Mekong. New roads of excellent construction lead on down to Tayninh, and sixty miles more through villages, paddy fields and forest, bring Saigon and the choice food and coolness of the Continental Hotel. Sitting under electric fans on the outdoor terrace, with every convenience and comfort, one is again in a Paris set down in the soft evening air of the tropics, among palms and orchids, with a busy, colorful street demanding attention and questions of steamer and money-changing obtruding. Angkor grows remote and hazy. Its influence departs. It becomes a misty dream, of half-imagined, half-remem-

bered fantasies. But to the thoughtful traveler, its name will always arouse inarticulate memories and a consciousness of something deeper than speech and more intimately portentous than the sounds and sights of the work-a-day world.

The ruins of Angkor Thom stand a mile and a half square, with a wall in almost perfect condition to-day, and the temples and royal houses inside still in good preservation. It is dominated by the great Bayon Temple, with its fifty towers and hundreds of rock-carved faces. The great square pillars of the lower terrace have on each side three dancing apsaras, whose lithe grace is seen even in the Cambodian dancing girls of to-day. A mile or more outside Angkor Thom is the renowned Angkor Wat, or Great Temple, originally dedicated to Siva, and then the overflow of Buddhism turning its worship toward that of the Master of the Yellow Way. Originally there is no doubt that the great central tower, which was open to worshipers on all sides, housed the lingam of Hinduism. Now this tower is divided into four recesses, the one facing west having in it a bronze Buddha of great beauty. In fact, a small Buddhist community lingers still within the confines of the outer enclosure.

The Wat is built of gray sandstone on foundations of laterite in enormous blocks. It is covered throughout, inside and outside, by the most meticulous carvings in low relief, depicting, presumably, the history, achievements and personal grandeur of the rulers of ancient Cambodia. One series of these carvings refers to the conquest of Siam. Finally, in turn, Siam revolted and conquered the mother country, carrying off the Emerald Buddha of Angkor to Bangkok. The Cambodian king then became a vassal of Siam until the French Protectorate was established in 1867.

GIANT TRUNK AND AIR ROOTS OF A DIPTOCARPUS.

CHIEF ASCENT IN ANGKOR WAT
SHALLOW, HIGH STEPS LEAD STEEPLY UP TO THE HIGHEST TOWER.

The outer enclosure, which is over 6,000 yards in circuit, is crossed by a huge causeway for elephants made of enormous stone blocks and leading a quarter of a mile across the great surrounding moat of the inner temple. Traces of gold and gilt decorations are still to be seen in places, and originally there must have been a shining mass of metal used in decorations and representations. The main group of buildings consists of three great tiers of galleries. Groslier, quoted by Miss Wheatcroft, says that the Khmers excelled in artistic skill, but were deficient in invention, as shown by the endless repetition of patterns in the carvings. Groslier refers to the latest-built of the great temples, the Angkor Wat, as the Triumph of Intelligence, because of the symmetry and perfection of its planning as a whole. He calls the Bayon the Triumph of the Soul, because it shows signs of gropings after change.

Groslier says the Khmers were not architects and were lacking in the science of building in spite of the luxurious civilization of the tropics in which they lived. They were great artists, but their construction principles were rudimentary and showed no evidence of improvement as time went on. From India the Khmers took their intellectual endowment in religion and mythology, but their use of stone was limited by their previous knowledge of the use of wood, as for instance, for beams and boards and the support of superstructures. In India it is common for the low temples to be surrounded by high gopurams or entrance-gate towers, while at Angkor the Holy of Holies is under the central, highest and most magnificent tower. However, the vast influence of Hindu mythology is seen throughout the bas relief, and in the very structure of the temple with the surrounding ceremonial tank or pool of holy water. Strangely enough, in all the miles of Angkor carvings, there is no obscene figure, in striking contrast to the conspicuous obscenity of Hindu temple decorations in India.

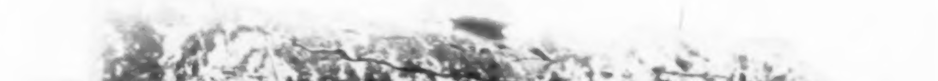
The Khmers brought their more material civilization, evidently, from China. This probably came in with the first great wave of Buddhism. Weights, measures, all matters of practical everyday living, came from South China, or even from Central Asia, and were direct accompaniments of Buddhism.

The old history of organized hospital medical service is an interesting commentary on the recognition in those times of the need of combatting disease. This recognition points to the existence of disease as a real problem. It is safe to infer that the great stream of pilgrims came from distant Buddhist lands and that the temple worship, then as today, gave opportunity for the spread of contagious diseases among the worship-

pers and their epidemic distribution by returning pilgrims. They indicate that tropical disease played no small part in the downfall of Angkor.

It is an astonishing thing that an empire of the magnitude, richness and culture shown by Angkor in its glory, should have made so small impress on the world of that day and finally should have been completely lost to human knowledge and destroyed without more records in adjacent countries. Consideration of story, legend and written history, so far as it can be deciphered from the rock carvings, indicates that in the thirteenth century the Siamese and other Thai tribes to the north were tributaries to Angkor. Constant wars against these and against the Chams to the east went on for centuries. Eventually these barbarians overcame Angkor.

It is impossible to believe that a city as rich and powerful as Angkor, in a country as populous as ancient Cambodia, could suddenly be wiped out by revolt of one particular group of people tributary to it. There must have been predisposing causes. We have in this connection to remember that history does repeat itself, and that the same is true of cycles of disease. Epidemics and pandemics come with fair regularity, and the course of civilization has, on the whole, been influenced more by disease than by purely political and military causes. Applying these principles to the story of Angkor, we are forced to the conclusion that disease conditions of some sort weakened the people to the point where rebellion was possible on the part of the Siamese, with destruction of the mother country. In no other way does it seem possible to explain the complete disappearance and destruction of this wealthy, populous and powerful empire, sunk without a trace in the green-



EARLY MASONRY

STYLE IN DOORS AND BUTTRESSED WALL POINTS TO WOOD-WORKERS AND NOT MASONS.

ery of the jungle, with no clue to the cause of its disappearance either in its own ruins or in the records of surrounding nations. The mystery of Angkor ranks with that of Easter Island, of the Zimbabwi ruins in Rhodesia, of Borobodor in Java and of the pyramids of Yucatan.

Death comes quickly in the tropics, strikes with little preliminary preparation, often with slight warning, and frequently leaves no trace of its passage. The fate of Angkor, the curse of Angkor, is to be found, therefore, in that sudden pestilence which walketh in the darkness of the jungle and which struck at noonday on this fair city and nation with such disastrous results. We know that Greece and Rome fell before malaria. We know that Egypt fell before hookworm and Bilharzia. We know that the tsetse fly swerved the host of Islam northward out of Africa into Europe. We know that Panama fell before yellow fever and malaria, and so through a list of major historical events. To put an exact name on the curse of Angkor is not possible, because there are no records as to what type of disease afflicted the people in the years preceding their military conquest by the Siamese. We do know from the general study of medical history, however, that diseases now important and dangerous in this same locality and in the Far East in epidemic form were undoubtedly present in those early days, and among them furnish the cause of Angkor's fall. Leprosy is mentioned by the old Chinese traveler, Chow Ta-quan, as being exceedingly prevalent. It is so to this day. Leprosy, ordinarily, is of such slow development and spreads so slowly that it does not assume major importance in the course of empires and political events. However, it may well have furnished part of a disease background which led to disaster. It is always chronic and slow in its course, but its cumulative effect is tremendous, and it can not be excluded from the foundations of the downfall of Angkor.

Perhaps the most important single disease to consider in this connection is malaria itself. This disease to-day is perhaps the most important one to which man is subject, both in numbers of those afflicted, in economic losses, in death rate and in impoverishment of health and happiness. Tropical malignant malaria strikes suddenly, may kill within a day, and in regions which are favorable to its course may depopulate districts with astonishing speed. Here we must place, probably, one of the chief reasons for Angkor's disaster.

The Black Death of India, kala azar, has but to cross from the delta of the Ganges to Burma, to Assam and up into the Malay country in times past and up to the present. Here is a disease of a two- to three-year course, without modern scientific treatment invariably resulting fatally, spread rapidly through the medium of small, biting flies, and attacking entire populations, especially in jungle areas. It, too, can not be excluded from a major rôle in the tragedy of Angkor. Its conquest in the past decade is one of the monumental triumphs of scientific medicine, but in the old days it was one of the very Captains of the Men of Death. The dysenteries and typhoids are always with us, particularly in the tropics, and their rôle could hardly be primary in the situation we are now discussing. The same might be said of the effects of animals and snakes, which by their bites contribute to a considerable death rate. These factors were fairly constant and were probably much less in ancient times with highly cultivated fields than at the present.

The fall of Angkor may well have been hastened also by cholera, which still flows in epidemic waves over the southern half of Asia. Because an efficient

national quarantine keeps the United States free of this disease, we are prone to forget its devastating sway in countries which have no sanitary sense and where the natural causes of disease are unknown and ignored. Finally we must recall the influence of plague, which killed a fourth of the population of Europe in the thirteenth century and which has spread over the world in great pandemics from prehistoric to modern times. Noel's "Black Death" is worth reading. Even the very recent knowledge of the rôle of fleas in carrying plague germs to man from the great rodent reservoirs has not led as yet to complete conquest of this disease. If plague could kill Pericles and pave the way for the fall of Athens at Syracuse, it could also have been no mean factor in the swelling tide of disease that constituted the curse of Angkor.

Sixty years ago, the naturalist, Mouhot, struggled through the jungle of upper Cambodia in search of his game of natural life. By chance he came upon the massive ruins of Angkor, which thus again were restored to human knowledge after six hundred years burial beneath the green waves of the jungle. During that time the only known inhabitants of this great empire were the thousands of monkeys which scampered gracefully about its ruins, the white rhinoceros, the tigers and the abundant waterfowl and other animals which made it their home. A few scattered aboriginal inhabitants, who are probably, without question, the descendants of the ancient Cambodians, were found in scattered jungle villages. Wild as animals and with little except poorly understood folklore pointing back to their ancient ancestry, these people can throw no light on what happened or why it happened.

What the old French naturalist saw, and what the French archeologists have been gradually exhuming ever since, lies revealed to-day in part, with the jungle stripped back and the great stones replaced from the places whence they had fallen, the creepers and vines and impenetrable growth of the jungle torn away, so that we see over a diameter of fifteen miles a scattering of such colossal ruins as are seen in few other places in the world except Egypt.

The story of Angkor remains to be written in its completeness. But from the fragments and outlines now available, we can draw another great lesson from Asia. Death comes quickly the world around where medical science is unknown or ignored. The curse of Angkor has been the curse of many another race and nation. Sufficient knowledge is available to-day to prevent or control most of the disease plagues of mankind. Ignorance, indifference, poverty and superstition have always been as they are to-day, the sub-strata on which Asia has built her economic, social and political structures. Our American nation is 155 years old. Now, in its youth, it may, if it will, avert the fate that has terminated epochs, and submerged or destroyed civilizations of the past. Now it may make sure that the curse of Angkor is not repeated in the curse of America.

THE GROWTH OF NATURAL VEGETATION AS WATER CULTURES

By Dr. DACHNOWSKI-STOKES

PHYSIOLOGIST, U. S. DEPARTMENT OF AGRICULTURE

THE popular interest regarding a series of experiments affecting the growth of crops in nutrient solutions without any soil whatever, and the publicity concerning the methods variously called soilless farming, water culture, hydroponics, or some other term used in magazines, over the radio and in public lectures, have raised the question as to how widely the water-culture method finds practical illustrations in nature.

Laboratory experiments to determine the nutrient requirements of plants have been made by plant physiologists over half a century in several countries. The field is now adequately covered in textbooks used by agricultural schools and colleges and is supplemented alike by tests on the part of students and by research of teachers to determine the limiting factors in plant growth and food production.

The fundamental physiology of plants is the same, whether they are grown in a mineral soil, in an artificial nutrient solution or in organic material such as peat. In all instances, an adequate supply of water, sunshine, air and certain salts is of special importance. In fact, water always constitutes more than one half and usually about three fourths of the weight of plants grown as crops. Almost the entire dry matter of plants, except the portion left as ashes when plant materials are burned, consists of carbohydrates, such as starch, sugar, cellulose, as well as fats, oils and other organic compounds obtained chiefly from carbonic acid gas absorbed by green parts and produced by the plants during daylight with the aid of solar energy.

From what has been said it is evident that water and soluble mineral salts of various kinds form an important raw material, but it is necessary to comprehend their intimate relationship to individual plants as well as to groups, or plant associations, in order to understand the difficulties of hydroponics, or soilless growing methods. Emphasis is laid here upon the work of plants; how vegetation behaves when growing as a water culture, not in artificial tanks but in natural ponds, lakes and streams; what changes are brought about and how the watery environment shapes the course and character of vegetation.

Interesting aspects of these relationships are illustrated by the characteristics of a floating island of unusual vegetation located in Buckeye Lake, near Columbus, Ohio (Fig. 1). The island is known as Cranberry Island, and is utilized as a refuge for wildlife. Its general features, together with an extensive series of field and laboratory experiments, were described by the writer in a volume on the peat deposits of Ohio issued by the Geological Survey of Ohio (Bulletin 16, 1912), and more recently in Volume 7 of the "Handbuch der Moorkunde." The lake is of glacial origin, probably of Wisconsin age. It is surrounded by undulating hills, more or less wooded with deciduous trees. The Ohio State Canal, now abandoned, at one time traversed the county. A dike was constructed in 1830 around the western end and a part of the northern side of the lake. This dike caused the water level to rise eight feet above the original level, the ponded water acting as a reservoir for the canal. Most of the peat-forming swamp forest that extended around the shore was submerged, with the exception of a floating mat which

was completely isolated just off the shore on the northern bank of the lake. The "island" thus formed within the deeper parts of the present basin (Fig. 2) is grounded, but it rises and falls with seasonal variations in water level. Living sphagnum mosses and cranberries now occupy the center of the island, together with certain heaths characteristic of typical sphagnum bogs in northern Michigan. On the shores is a scattered growth of some of the former deciduous shrubs and red maple. Since the many different seeds brought to the island by winds and birds can not establish themselves, the natural vegetation has undergone no changes within 30 years.

Because of the proximity of the island to Ohio State University, it was possible for the writer to make a study of it from various view-points over a period of several years (Fig. 3). These investigations were concerned with the identification of the botanical composition and the characteristics of the early stages of vegetation, and with their coordination with chemical and other conditions in the lake as a water culture and those of the island as a nutrient solution, in which the sphagnum mosses and the maple-alder vegetation are growing.

Origin and Development of Cranberry Island

A clear indication of the origin and the stages in the development of the structural features of the island is furnished by its vertical profiles sections. The American peat-sampling instrument was used, and samples from each foot of material below the surface were taken to the laboratory for microscopic study. On this basis the individual layers of peat superimposed upon one another have the following characteristic composition and sequence (Fig. 4).

FIG. 1. MAP SHOWING LOCATION OF BUCKEYE LAKE AND CRANBERRY ISLAND, LICKING COUNTY, OHIO.

ADAPTED FROM THORNVILLE SHEET OF U. S. TOPOGRAPHIC SURVEY.

FIG. 2. CRANBERRY ISLAND

VIEWED FROM A HILL NORTH OF THE ISLAND NEAR BUCKEYE LAKE STATION.

The earliest plants in the lake's history were aquatic. They formed an olive-green to brown or grayish-black sedimentary peat. The organic material of which they were composed is completely disintegrated and more or less jelly-like. Under the microscope it shows a wealth of well-preserved plant remains, such as algal filaments, wind-blown pollen, seeds and fragments of pondweeds, and, occasionally, shells, diatoms, sponge spicules, marl from algae and bits of exoskeleton of insects (Fig. 4, A).

In the course of time reeds and sedges encroached, together with cattail. To the exclusion of other forms the tall grasslike vegetation built up a floating fibrous mat composed of innumerable roots interwoven with perennial underground stems. The efficiency of grasslike plants as a growth of this sort in open water without access to mineral soils is particularly obvious in marshes all over the world. The bulk of vegetation forms each year a new addition to the slowly increasing thickness of roots and rhizomes, and thus adds to the formation of a reddish to yellowish-brown fibrous layer overlying the sedimentary peat (Fig. 4, B).

At a later stage a large swamp forest developed. It occupied nearly all the ground along the lake shore, when the first settlement in this section was made. The swamp included deciduous trees and conifers whose root systems penetrated the fibrous peat material which was less saturated and in which partial drainage favored microorganisms, decomposition and mineralization. A radically different kind of peat resulted from the accumulating granular dark-brown woody residue and the fragments of fallen trees, branches of shrubs, leaves and other herbaceous materials of plants that formed the dominant cover of the swamp forest society.

In the great central lowland states generally there is no tendency toward the formation of sphagnum moss bogs. The vegetation stages usually pass through the marsh to swamp shrub and swamp forest. But under certain nutrient conditions, the course of vegetation may turn from the marsh stage to the bog stage. Cranberry Island, in its profile section which shows moss peat overlying reed and sedge peat (Fig. 4, C), justifies this statement.

Nutrient Conditions

The raw materials needed by green plants in water cultures have already been named. They are water, mineral salts and carbon dioxide, used for making, by the aid of sunlight, the carbohydrates and other organic substances that are the food of plants and animals, including mankind.

Natural bodies of open water, such as Buckeye Lake, hold much mineral matter in solution. Part of it is surface run-off from fertile or eroding surface soils and the percolating seepage of underground waters from mineral subsoils, and part is rainfall bringing with it various gases, mineral dust and other impurities from the air. Generally speaking, lake waters are found to contain calcium, potassium, magnesium and other salts, including minor minerals, such as iron, manganese, copper and rarer elements in minute quantities. They contain also carbon dioxide, with which water forms carbonic acid. This carbonic acid greatly increases the solvent power of the water and the chemical activity of the different mineral constituents it contains. Though the water on the margins of a lake may vary in the proportion of the nutrient substances it contains, the quantities in its central parts are kept nearly constant by solution and by free diffusion.

The water near the surface of Buckeye Lake is relatively transparent, while that of the island suggests a dilute-coffee color. The turbidity is due to colloidal organic material in suspension and is common in the waters of many bogs and lakes in northern cooler regions.

During the summer the temperature of the surface water commonly is a few degrees lower on the island than in the lake, the highest temperatures recorded at a depth of three inches being 77° F. and 82° F., respectively. Shading and intercepted air movements kept the water cooler (71° F.) in the maple-alder vegetation. At greater depths, below the surface of the growing roots of plants,

FIG. 3. STUDY PLOT IN CENTRAL PORTION OF CRANBERRY ISLAND

WHERE PROFILE SECTIONS WERE TAKEN AND VARIOUS INSTRUMENTS WERE USED TO DETERMINE CONTROLLING ENVIRONMENTAL CONDITIONS.

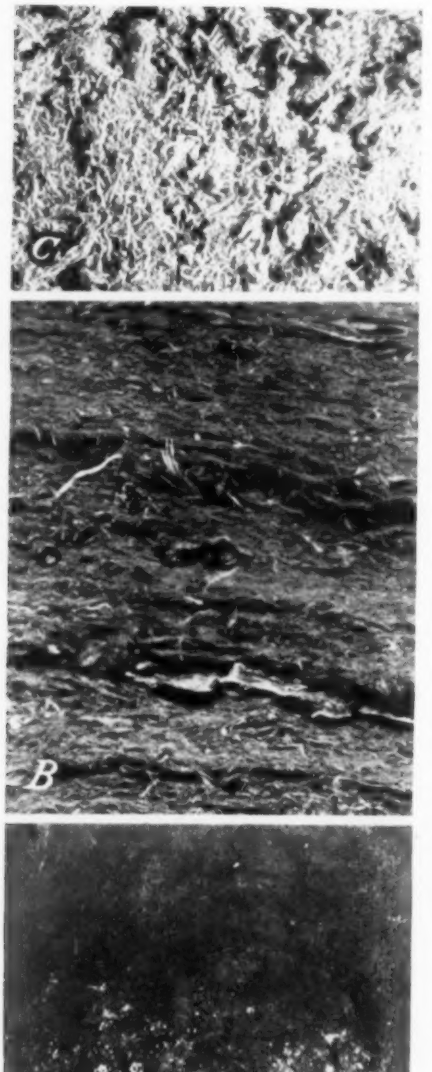


FIG. 4. PROFILE RECORD OF CRANBERRY ISLAND

INDICATING THE GENERAL COURSE OF DEVELOPMENT AND SEQUENCE OF DIFFERENT LAYERS OF PEAT: (A) PLASTIC SEDIMENTARY PEAT THAT ACCUMULATED FROM AQUATIC PLANTS; (B) FIBROUS SEDGE PEAT FORMED FROM A FLOATING MARSH VEGETATION; (C) SPHAGNUM MOSS PEAT WHICH DEVELOPED FROM THE PRESENT STAGE OF BOG ASSOCIATIONS IN WHICH CRANBERRY AND HEATH SHRUBS ARE CHARACTERISTIC.

the temperatures continued lower on the island without interruption throughout the year, while in the lake an annual descent and circulation of the warmer surface waters took place. Consequently resistance to heat changes is greater and layering of temperatures appears to be less interrupted on the peat-forming island than in the open water.

In the clearer water of the lake a considerable quantity of dissolved oxygen occurs, set free by aquatic plants as a by-product of photosynthesis. In the water of the floating island the amount of oxygen available for the roots of growing herbaceous plants is considerably reduced. Free carbon dioxide is present in appreciable but varying amounts at different times, being produced mainly by the decay of organic matter. Often the amounts of gas are greater with increasing depth below the surface. Conspicuous quantities of methane gas in and between roots of plants and layers of peat evidently are an outcome of stagnation and reducing conditions. Gas movement, like water movement, is known to be greatly retarded in peat.

Acid reactions are of particular interest because they have both direct and indirect influences on plant growth. The acidity or alkalinity indicated by pH determinations (pH 7.0 indicates neutrality) show a marked and abrupt change from the slightly alkaline condition (pH 7.5) of the lake water to the high acidity (pH 4.0) in the central part of the island, which coincides with the moss and heath vegetation. The acid-forming colloidal material appears to absorb and retain the basic ions of any salts dissolved in the nutrient solution. It affects the availability of essential elements and the activity of beneficial micro-organisms, and it leads to the formation of products that are poisonous when tested on cultivated plants. Although produced in sufficient amounts to maintain a relatively high degree of acidity, the organic constituents do not

diffuse through the layers of peat and are not transported into the lake by seepage.

The marked difference between the total mineral content of the lake water and that of the peat island is notable. Tests showed that the total solids varied from 309 parts per million in the lake water, to 196 parts per million in the water of the growing sphagnum mosses. In the marginal maple-alder zone the mineral solids increased to 423 parts per million. They represent stored nutrients intermixed with the woody fibrous peat, the liberation of which depends largely upon biological processes of decomposition. This indicates clearly that the absorption and retention of salts by peat materials is very great, creating an unfavorable balance between acid and base elements for absorption by plants. On the other hand, the nutrient solution of the growing vegetation in the interior of the floating island contains a very low total supply of essential mineral salts required for growth. The small amounts that affect growth either are deficient in necessary nutrient elements or they are unavailable because they are locked up in chemical compounds which the plants can not use. The salts from the mineral substratum and from the lake waters do not reach the interior of the island or the surface to supply the needs of the vegetation growing in a water-logged, undrained area of peat.

The small quantity of nitrogenous material derived from decaying organic matter and other sources, such as nitrites, nitrates and nitrogen as free ammonia, ranged from a few thousandths to a few hundredths parts per million, probably because decomposition proceeds more slowly under conditions of a high water table, and the nitrogenous products are rapidly taken up by the growing vegetation. The higher amounts occur in the lake water, pointing clearly to the fact that nitrogenous decomposition products arise mainly through the action of aerobic micro-organisms.

The evidence indicates that various types of natural vegetation, ranging from aquatic plant associations to those of marshes, bogs and swamp forests, are the product of water cultures growing without access to mineral soils.

Combining the major physical and chemical data, determined over a period of several years, with other circumstances prevailing on the floating vegetation of the island at Buckeye Lake, Ohio, it seems necessary to conclude that the maintenance of nutritional requirements favorable to particular plants growing without a mineral soil involves much experimental work and many difficulties. Certain changes occur, the general tendency of which may be designated as a change to acid reactions, which are accompanied by changes in nutrient and other conditions for the growth of plants. Present information does not warrant a prediction as to how widely a water culture method may find practical application for crop production. The maintenance of favorable nutrient solutions requires periodic study of the factors that affect plant growth, cause malnutrition or support diseases. The necessity for changing the nutrient solution to meet the needs of individual crops calls for physical and chemical analyses, continued control and adjustments of culture solutions, and knowledge of elementary principles of ecology and plant physiology. It is concluded, therefore, that the growth of natural vegetation and of garden vegetables or other agricultural crops in water culture is still in the experimental stage, and is not yet ready for practical applications or as a commercial venture.

THE STUDY OF TWINS

By Dr. D. C. RIFE
THE OHIO STATE UNIVERSITY

POPULAR interest in twins and multiple births has grown rapidly in recent years. As a result much interesting information has become available, but at the same time many erroneous opinions respecting the nature and interpretation of twin studies have arisen. It seems appropriate to discuss briefly at this time the twin method of research.

The increasing popular interest in twins is manifested in the formation of Twin Associations, the holding of Twin Conventions and parties and the sponsoring of Twin Contests. It has been the good fortune of the writer to attend several of these events for scientific purposes at the invitation of the twins themselves. One of these occasions offered the unusual opportunity of examining a pair of twins who had been separated for a period of years. Their histories will serve as a convenient introduction to the discussion of the twin method.

On August 16, 1938, 165 pairs of twins held a party at Lakeside, Maine. The party was sponsored by Mr. Welton Farrow, to celebrate a visit from his identical twin brother Harold, whom he had not seen for nineteen years. Because of their long separation and their different environments, the Farrow brothers present cases of unusual value to those interested in the nature-nurture problem. They were kind enough to give the writer their life stories and also to submit to various tests and measurements.

They were born on a small farm in Prince Edward Island on December 10, 1897. Their father was a sea captain, who lost his life during the world war when his ship was sunk by a German submarine. When the twins were ten years of age, their family moved to Saskatchewan, remained there four years, and then returned to Prince Edward Island. In the spring of 1913 Welton went to Portland, Maine, and apprenticed himself to a carpenter, with whom he remained until August, 1914. Then he returned to Prince Edward Island and enlisted in the Canadian militia, serving in the Halifax garrison. In April, 1915, he was discharged on account of fallen arches. Returning to Portland, he spent four more years as a carpenter's apprentice, after which he had to discontinue carpentering because of his fallen arches. For the next two years he was railway Y.M.C.A. secretary for the Boston and Maine and the Maine Central railways. He states that while engaged in this work he came into contact with educated people, and became ambitious for more schooling. Consequently, he entered and worked his way through Hebron Academy, taking a four-year course in three years and graduating in 1922 as valedictorian of his class. He next spent three years in Bates College and then one year in New Hampshire State University, from which he graduated in 1926 with honorable mention. Welton states that mathematics and science were easy for him, but that he had great difficulty with languages. He worked as a carpenter for one year after his graduation. In 1927 he became business manager for Swavely School, of Manassas, Va., holding this position until 1930. From 1930 to 1932 he was superintendent of maintenance for Colby College, of Waterville, Maine. In 1932 he opened a bookshop, which he is still successfully operating. He is married and has one child, a girl five years old.

The life story of Harold is somewhat

different. After the return of his family from Saskatchewan, Harold remained in Prince Edward Island a year longer than did Welton, and then went to Worcester, Mass., where he apprenticed himself to a machinist. In 1916 he joined the Canadian army and was at the front when the armistice was signed. After leaving the army, Harold went back to Worcester, working as a machinist until the spring of 1920, when he went to Winnipeg, Manitoba, where he still lives. While in Worcester, Harold took a course in mechanical drawing at a night school. Harold is still a machinist and, interesting enough, invented and patented a new type of skate sharpener a few years ago. He is married, but has no children.

A glance at the Farrow brothers is sufficient to convince one that they are single-egg, or identical, twins. At the twin party people continually confused them. They have swarthy skins and dark hair and eyes, with no visible differences in degree or type of pigmentation. As shown in Fig. 2, both are bald to approximately the same extent. A comparison of their palm and finger prints revealed the fact that similarities of the two right hands and of the two left hands are greater than that between the right and the left hand of either individual. Plaster of paris impressions of their teeth also show striking similarities. Other physical measurements are given in Table 1.

TABLE 1

	Welton	Harold
Height	64"	64¼"
Weight	148½	157½
Blood pressure		
Systole	115	124
Diastole	70	76
Blood group	A	A
Blood type	MN	MN
Unimanual handedness	Right	Right
Bimanual handedness	Left	Right

It is of interest that Harold has never been troubled with fallen arches,

FIG. 1. THE FARROW TWINS. WELTON IS STANDING IN FRONT OF HAROLD.

whereas Welton has been badly handicapped by them at times. Harold has flat feet, however, but not as extreme a case as Welton.

Since they offer rather extreme differences in education, as well as in occupations and environment, the results of the psychological tests of them are of unusual interest. Previous to their separation, each had about the equivalent of a grammar school education. The tests[1]

[1] The tests were scored and interpreted by Professor W. L. Valentine, of the Psychology Department of the Ohio State University.

FIG. 2. ILLUSTRATING SIMILARITIES IN BALDNESS. HAROLD IS ON THE LEFT, WELTON ON THE RIGHT SIDE.

given included the Pressey Test of Reading Speed and Comprehension, the Pressey Interest-Attitude Tests, Thurstone's Scale of Attitude toward War and the Bernreuter Personal Inventory. Their scores are given in Table 2.

The average number of words read per minute was 119 for Welton and 102 for Harold. In reading comprehension, we find that Welton was in the top 10 per cent. of a college population and Harold in the top 20 per cent. The difference of 10 centile range between Harold and Welton is significant and means that Harold is somewhat slower in comprehending what he has read.

Since the twins had been separated for many years, one might expect quite different scores in the War Attitude Test. It does not turn out, however, that there is any significant difference in the twins in this respect, both being definitely opposed to war and warlike measures, as is indicated by a scale value of 3.3 and 3.6, where 6 represents neutrality of opinion.

TABLE 2

	Welton		Harold
Words read per minute	119 lowest centile		102 lowest centile
Comprehension	90 centile		86 centile
Attitude toward war	3.3		3.6
Interest attitude		(College SR.)	
Things thought wrong	+ 7	+12	+3
Worries	0	− 6	0
Interests	− 1	− 5	+7
Likes	−12	−19	−22
Total age score	21 years		21.5 years
Bernreuter Personality			
Neurotic inventory	4 centile		37 centile
Self-sufficiency	69 "		29 "
Introversion	5 "		42 "
Dominance	52 "		46 "

In the Interest Attitude Test we can obtain a total score which gives Welton an emotional age of 21 and Harold one of 21.5 years. This would mean that Harold is somewhat, but not significantly, more mature than Welton. The various subject tests of the Interest Attitude Scale indicate that both of these men are more mature than the typical college freshman, but not quite so mature as the college senior. This is especially true in connection with the "things worried about," where neither marked a single item.

The Bernreuter Personality Inventory gives us four separate scores which do reveal differences between the twins. Both are less neurotic than the usual college population, but Welton is significantly less neurotic than Harold. Welton is also very much more self-sufficient than Harold, as is indicated by a centile score of 69 compared with his twin's of 29. This self-sufficiency test reveals that he does not depend habitually upon other people. The most significant difference exhibited is probably in the measure of scores at the 42 centile level. Neither of the twins is as introverted as the average college student, but there still is a wide difference between them. In dominance, although the difference is somewhat less significant than it has been in the other measures, we still find that Welton is the dominant individual.

To summarize, the tests suggest that the twins are tenacious and profit by whatever experiences they have. They are particularly free from worries, and neither of them is neurotic nor so introverted as the average college student. They differ in that throughout Welton scores higher than his twin, which is not surprising considering Welton's more extensive education. It would be enlightening to know how they would have compared on similar tests previous to their separation nineteen years ago. Of course, these psychological tests, unlike the various anatomical measurements, are subject to considerable measurement error, and although they are satisfactory for distinction between groups of people, they have certain properties that are not entirely reliable for individual diagnosis. We are desirous of obtaining similar data from a sufficient number of separated identical twins to enable us to draw valid conclusions regarding the effectiveness of environment in bringing about variation in the traits measured.

In order to obtain exact information regarding the relative rôles of heredity and environment in bringing about variation, it would be ideal to have for examination twins offering the following four combinations of factors: identical heredities, identical environments, totally different heredities and totally different environments. Thus we could compare the following four types of individuals; those with identical heredities and identical environments, those with identical heredities and different environments, those with different heredities and similar environments and those with different heredities and different environments. It is generally assumed that identical, or one-egg, twins reared together furnish the first type, identical twins reared apart the second type, and fraternal twins reared together the third.[2] Actually, only in the first instance, that of identical twins reared together, do we approximate our goal. With the exception of mutations which may have occurred after separation of the embryos, identical twins have the same genotypes. Their environments are more alike than those of any other paired individuals, due to the fact that their similarities in general appearance are usually sufficient to cause all but close acquaintances to react to them as to a single personality.

[2] On this same basis, fraternals reared apart would furnish the fourth type, but no such studies have as yet been made.

In the case of identical twins reared apart, while having identical heredities, the amount of differences in the environments is highly variable, and in no instance of such pairs as yet recorded have the environmental differences been extreme. If we were interested in determining the maximum differences environment might bring about, we might compare, for example, the members of pairs of African pigmy identical twins, one member of each pair having been reared with his pigmy relatives, and the other by cultured, educated and wealthy Europeans or Americans. Furthermore, the pair showing the greatest intra-pair differences, rather than the mean intrapair differences of the groups, would give us a type of the measure desired. From the practical standpoint, however, we are more interested in how much of the variation between individuals, *on the average*, may be attributed to environment, and thus means rather than extremes answer the purpose satisfactorily. In any statement concerning the part played by environment in producing differences, it is of course essential to specify the type of environment, as well as the type of traits measured. Identical twins reared apart may still have quite similar environments educationally, culturally, financially, religiously and in numerous other respects. The twins we have just described, while reared together, have had unusual differences in education and different vocations and nationalities. Different types of environment are, of course, not necessarily additive to their ability to produce variations. In spite of the above-mentioned limitations, identical twins exposed to different environments give us our most accurate material for evaluating the rôle of environment in producing differences.

The assumption that fraternal twins reared together have different heredities and similar environments is the most hazardous of the three. As previously pointed out, identical twins when reared together have more nearly similar environments than any other paired individuals. We react to the members of fraternal twin pairs as two distinct personalities. It is possible that some pairs of fraternal twins have less nearly similar environments, on the whole, than some identical twin pairs reared apart. Comparisons of identical twins reared apart with fraternal twins reared apart should throw light on the problem.

Fraternal twins have, on the average, the same degree of genetic similarity as brothers and sisters. If we desired to determine the maximum differences heredity can produce between individuals, we should examine pairs of extremely different heredities, reared in as nearly similar environments as available, and base our conclusions on the most dissimilar pair. To refer to our former illustration, the natural children of Caucasian pairs, compared with their Negro pigmy foster brothers or sisters, should furnish data of the desired type. But here again, we are more interested in how much difference, on the average rather than as a maximum, may be attributed to heredity. Comparisons of the above type are, of course, not feasible, and, furthermore, it is possible for brother and sister pairs to possess the most extreme ranges of genotypic variation. Nevertheless, the mean genotypic similarities of brothers and sisters are greater than those of unrelated individuals. Thus foster brother and sister comparisons should give us more accurate data for evaluating the rôle of heredity.

Comparisons of fraternal twins, however, furnish data of unique value in nature-nurture studies. Being contemporaries, comparisons with brothers and sisters give us a measure of the degree to which variations between brothers and sisters may be the result of age differ-

ences, although it should be remembered that fraternal twins also have slightly more nearly similar environments. Another important use of fraternal twin data is in obtaining an estimate of the part the unusual prenatal environment of twins plays in bringing about variation. Obviously, due to position *in utero*, crowding and other circumstances, the prenatal environment of twins of each type is different from that of single-born individuals. Handedness is an interesting example of a trait affected by the position *in utero*. In both types of twins the percentage of left-handedness is greater than in single-born individuals. The excess of left-handedness in twins must be due to some prenatal factor operating only in twins.

The observation that the prenatal environment of twins is sufficiently different from that of single-born individuals to be a factor in producing differences in twins emphasizes the need for caution in drawing conclusions from twin data alone. Although any differences present in a pair of identical twins must be due to factors other than heredity, such differences do not imply that the trait does not have a hereditary basis. We have previously mentioned the fact that left-handedness occurs more frequently in twins of both types than in single-born individuals. In about a fifth of identical twins we find reversals of handedness within pairs, that is, one member right-handed and the other ambidextrous or left-handed, or one left-handed and the other ambidextrous. There is definite evidence that an association exists between handedness and the surface patterns of palms and fingers. This with the fact that left-handed parents have a higher percentage of left-handed children than do right-handed parents, indicates that handedness has a hereditary basis. Our data on the handedness of 166 pairs of twins and their immediate families show a significantly higher percentage of left-handers among the relatives of pairs showing reversals than among those pairs having the same handedness. The probable explanation is that those pairs showing reversals are genotypically more nearly ambidextrous than those pairs in which no reversals are manifest, and the unusual position *in utero* is sufficient to shift the handedness of such individuals one way or the other.

In identical twins reared together it is not at all unusual to find slight intra-pair differences in such quantitative traits as stature, weight and I.Q. Ordinarily the same member of the pair is superior throughout, although strikingly similar to his mate qualitatively. Such intra-pair differences are most likely due to conditions *in utero* peculiar to twins, such as an imbalance of blood supply, crowding and other circumstances. Differences of the above type are manifest in the Dionne quintuplets, Yvonne being slightly larger and rating superior to the other in psychological traits, whereas Marie is the smallest and has the lowest psychological rating. Such differences, while not great as compared with ordinary brother and sister differences, must be considered in the analysis of twin data.

Contrary to popular impressions, studies of fraternal twins may indicate the exact mode of inheritance of traits involving only a single pair of factors. Twins are frequently classified as concordant or discordant in respect to given traits. For each mode of single factor inheritance and each gene frequency the ratios of discordant to the various types of concordant pairs can be accurately determined. For example, it can be shown that any trait for which there are only two phenotypes, and in which significantly more than 27 per cent. of fraternal twins are discordant with similar ratios in both sexes, can not be due solely to a single pair of au-

tosomal factors. Unfortunately, data in regard to concordance in twins are usually taken in such a way as to refer only to that concordant type in which both members of the pair manifest the trait in question. Without the percentage of concordant pairs in respect to absence of the trait, fraternal twin data tell us nothing of the mode of its inheritance, for we are dealing with a selected population. For traits in which we are reasonably certain that the differences in degree of similarity of the environments of the two types of twins reared together are insufficient to produce variations, the excess of discordant pairs occurring in fraternal twins over that of identical twins may be interpreted as the extent to which intra-pair differences in fraternal twins may be attributed to their different heredities. For example, Diehl and Von Verschuer recently studied 239 pairs of twins in Germany, in each of which one or both members of the pair had tuberculosis. In the identical twins, 80 per cent. of pairs were concordant, whereas in fraternal twins only 25 per cent. were found to be concordant. The natural interpretation is that 55 per cent. of the fraternal twins investigated are discordant due to differences in heredity, whereas 20 per cent. are discordant, as in the identicals, due to other factors.

But, as we have previously indicated, such interpretations are not necessarily valid for traits which may be easily modified by the similar environments of identical twins reared together. Another German investigator, Lange, several years ago studied both types of twins in regard to concordance in crime. He found a high degree of concordance in identicals, and a correspondingly high degree of discordance in fraternals. These findings are often interpreted as proving that criminal tendencies are hereditary. Obviously, such conclusions are not necessarily valid. If one has an identical twin who is known as a criminal, it certainly is not conducive to good conduct to be frequently mistaken for the criminal brother. Similar studies with twins of both types reared apart would be enlightening.

Numerous investigators agree in finding mean intra-pair differences of approximately five in the I.Q. for identical twins reared together. Newman and his colleagues found a mean difference in I.Q. of approximately 9 points for their twenty pairs of identical pairs reared apart. Hildreth found a mean difference of 14.5 points for brother and sister pairs reared together, and 15.5 for brother and sister pairs reared apart, an insignificant difference. She also found a mean intra-pair difference of 17.7 points for unrelated pairs, whether reared together or apart. The greater differences between identical twins separated and together suggests that the similar environment of identical twins is a factor to be considered in the interpretation of I.Q. differences. It is only fair to add, however, that with the exception of the identical twins reared together, the number of individuals measured were too small to give highly reliable mean values.

As previously pointed out, foster sibs reared together *vs.* identical twins reared together should give us a better measure of the influence of heredity than a comparison between identical twins reared together and fraternal twins reared together. Better still, foster sibs of the same age could be selected. But the difficulties in obtaining such pairs are fairly great, and, too, we have failed to take into account the more nearly similar environments of the identical twins. We are attempting the alternative approach to the nature-nurture problem of comparing identical twins reared together with identical twins reared apart or subjected to various types of environmental differences. This gives us an estimate of the rôle

of postnatal environments in producing differences. And we are also comparing fraternal twins reared apart with brothers and sisters reared apart, from which we may obtain an estimate of the rôle of the prenatal environment of twins and also of the age factor in producing differences. That is, if fraternal twins are less nearly similar than sibs, we may assume the difference to be due to prenatal factors; if the fraternal twins are the more nearly similar, age discrepancies are the differentiating factor. Our final group would be unrelated individuals reared apart, or subjected to various environmental differences. Such a group should be easily collected, and the differences between this group and identical twins reared apart would thus give us an estimate of the rôle played by heredity in bringing about differences. By this method we shall furthermore eliminate the problem of determining how much more nearly the environments of identical twins reared together are than those of other paired individuals. Or, better still, such data, when compared with fraternal twin data from those reared together, should give us a means of evaluating the part played by such more nearly similar environment.

The greatest need, and the most difficult to fulfil, by whatever method used, is that of obtaining more pairs of twins reared apart or twins subjected to various environmental differences. But when one considers the fact that there are over 1,000,000 pairs of twins in the United States, about a fourth of whom are identical, it seems premature to assume that all possibilities have been exhausted. The growing popularity of twin conventions and parties and the willingness of twins to cooperate in the collection of data are most encouraging. We earnestly appeal to any one knowing of separated twins, of whichever type, to inform us. We have as yet barely scratched the surface of the possibilities of twin research and its value to mankind.

A SCIENTIFIC BASIS FOR MORAL ACTION

By Dr. MAX SCHOEN

PROFESSOR OF PSYCHOLOGY AND EDUCATION, CARNEGIE INSTITUTE OF TECHNOLOGY

THIS paper is an exposition of the thesis that a scientific foundation for moral action is not only possible but that it is the only foundation that can bring about results that are at all desirable. A scientific search for moral principles must be guided by four criteria:

(1) That a principle to be applied to man must be derived from man, must be consistent with the facts of man's nature.

(2) That if conformity to a principle can be obtained only by compulsion, of whatever variety, it is an indication that that principle belies human nature, since a principle that is true to the nature of any material is in conformity with that material, and the material therefore already obeys that principle.

(3) That if a principle is consistently violated by the material to which it is to be applied, it is the principle that is false, and not the material that is obstinate. A material can not be wrong, but a conception of its nature can be false.

(4) That if a principle fails to bring about expected or desired results in the realm in which it is applied it is the principle that is at fault and not the realm in which it is supposed to operate. If a medicine fails to cure a disease it is the medicine that is wrong and not the disease. The disease can not be wrong.

Since these four criteria represent scientific caution, it follows that a principle for moral action that is consistent with these criteria has scientific validity. And such a principle in the history of moral theory is found in the Socratic conception of virtue as knowledge as expounded in the Protagoras. The discussion between Socrates and Protagoras arises from the circumstance that Protagoras, a Sophist, a public teacher of virtue, tells Socrates that the young men who come to him for instruction increase in virtue day by day, that every day in every way they get better and better. Socrates expresses doubt as to whether virtue can be taught, which brings about a discussion regarding the nature of virtue. The discussion opens with Socrates raising the question as to whether virtue is like the parts of the face, each of which is independent of the others, in that each can exist without the others, and each of which is distinctive from the rest in structure and function, or whether virtue is like the parts of gold, all of which are of the same quality and can differ only in size. If virtue is like the parts of gold it can be defined, its nature can be determined, in which case it becomes knowledge and can be taught. On the other hand, if virtue is like the parts of the face the virtues can only be named, and enumeration is not a definition or knowledge. To state this differently: if we say that virtue consists of honesty, truthfulness, loyalty, and so on, we know nothing unless we proceed to define these terms and show why they are virtue, which only leads us to a need for a definition of virtue itself. On the other hand, if we have a definition of virtue itself we also have a definition of every specific virtue, since a definition of the whole is also a definition of its parts, a part being a partial manifestation of the whole of which it is a part.

In insisting upon a definition of the nature of virtue rather than an enumeration of the virtues as the way to a knowledge of virtue, and thereby making of virtue something teachable rather than preachable, Socrates brings virtue into the sphere of science, of investigation, of inquiry. And this is inevitable. For the moment we insist upon a definition that is to tell us the nature of a thing in terms of the real thing itself our procedure for reaching such a definition, if we adhere strictly to what we profess to wish to know, must be scientific, for we discard all preconceptions, reject all dogmatic statements, and insist upon verification of results. In so far, then, as Socrates calls for a definition of virtue that consists of a determination of its nature, and rejects a definition that only lists a number of disconnected items each of which itself stands in need of defining, his approach is scientific.

After Socrates had shown that knowledge lies not in enumeration and specification, but in generalization, that virtue must be defined as we would define gold rather than a face, he proceeds to the main issue, namely, if virtue is knowledge, it must lie in the knowledge of something. What, then, is this something knowledge of which is virtue? It is my main purpose to indicate that the conclusion Socrates reaches in answer to this question is also scientific, in that it is supported by what we know to-day about human nature through the science of psychology.

The gist of the Socratic conception of knowledge as virtue lies in such statements scattered throughout the Protagoras as that a person may live inferior to himself, that to prefer evil to good is contrary to human nature, or that it is absurd to say that a person knows what is good but because he is overcome by pleasure he does evil. The implication throughout is that at any and every occasion one does that which one knows, and if the action results in evil it is not because evil was chosen but because the knowledge was defective. Now in what way can a man's knowledge about his behavior be defective? The answer is that he can mistake the lesser for the greater, the immediate for the remote, or, in other words, he can act impulsively or habitually instead of by choice, discrimination or deliberation. When a person acts in the former manner he is acting inferior to himself, in that his action is below his capabilities. And it is action in which something is mistaken for something else, a case of mistaken identity, that leads to evil, since a person is acting under a delusion, and brings about consequences that are harmful to him. But he does not purposefully deceive himself, he does not deliberately mistake the lesser for the greater. The only reason why he does the lesser is that at the time it appears to him to be the greater, that is, the most desirable. The inferiority of a man to himself arises out of ignorance, while the knowledge that spells virtue is the knowledge of magnitudes, of lesser and greater, and the art of virtue is therefore the art of measurement, of discrimination. Socrates' own summary of the conception of the nature of virtue is as follows:

> Now suppose happiness to consist in doing or choosing the greater, and in not doing or in avoiding the less, what would be the moving principle of human life? Would not the act of measuring be the saving principle; or would the power of appearance? Is not the latter that deceiving art which makes us wander up and down and take the things at one time of which we repent at another, both in our actions and in our choice of things great and small? But the art of measurement would do away with the effect of appearance, and, showing the truth, would fain teach the soul at last to find rest in the truth, and would thus save our life. Would not mankind generally acknowledge that the art which accomplishes this result is the art of measurement?

When we translate this philosophical language of Socrates into psychological terminology we find that the definition of virtue as the art of measurement reduces itself to the conception of moral action as action in keeping with human intelligence, that is, a human being living as a human being can live because of his place in mental evolution. It is the mental stature of man that makes of him a moral being. In other words, it is the moral action that distinguishes man from infra-human organisms, and moral action is synonymous with action that is indicative of the operation of human intelligence. To define morality scientifically, therefore, all that is needed is a definition of human intelligence.

The behavior of all animal forms is intelligent, in that it is selective, discriminatory, motivated activity. All that intelligence then means is activity stimulated by the environment, but directed and controlled by the organism itself. The stimulus influences, but does not determine the response. Selective behavior means behavior in which the acting agent is also the determining factor in the behavior performed, so that without a complete knowledge of the present condition and the past history of the acting body no prediction of the ensuing behavior is at all possible from the stimulating situation alone. Since the term intelligence is applied only to the activities of animal life, and since the distinguishing characteristic of animal activity is selectivity, it follows that selectivity is the sign of intelligence, and also that the degree of selectivity of behavior is the sole indication of the degree of the intelligence of the behavior.

Man is the most intelligent of animals because of the degree of selective behavior of which he is capable. The selective behavior of the animal is on a motor level. When a situation presents itself the animal will react to it either by an established habit or it will engage in a series of exploratory movements which will result in the setting up of an habitual response. Even the alleged learning by insight of some of Köhler's apes was on a motor level, in that the insight took place only, if it took place at all, after the motor trial and error had failed. Man is capable of dispensing entirely with motor exploration and to engage only in selective activity that is the fruit of mental exploration, or thinking proper. He can make anticipatory adjustments, can make exploratory movements in his mind, so to speak, and to engage in motor activity only after having reached a decision as to what he really wishes to do. The factors that enter into the making of the final decision are of no importance in the present connection. The important point is that this ability for what we may call delayed behavior by thought lifts man to the pinnacle of selective behavior, namely, knowing what he is doing, because he can deliberately proceed to know before he does.

This ability of man to look before he leaps, and thereby learn by looking rather than by leaping, assumes two forms. Human selective activity can be either activity that consists of discriminated means for the accomplishment of unconsidered ends, or of discriminated ends that necessarily also imply considered means. In other words, the thought problem before the person may be only that of determining the most expedient way of accomplishing a goal that appears desirable, or it may consist of an examination of the desirability of the goal itself. And it is these two forms of human selective activity that lead to an identification of morality with human intelligence. Moral action can not consist in the pursuit

of indiscriminate ends by discriminate means, for such action invariably and inevitably leads to a rationalization of the ends pursued, and rationalization is humanly unintelligent, since the need for it arises from the failure to use human intelligence in its complete form. Furthermore, even if some animals do learn by mental manipulation, its fruit is always the selection of means, never of ends, and consequently, a human being acting in that manner is living on the level of animal and not of human intelligence. To put this in Socratic language, the person who pursues uncritical ends by critical means is ruled by the lesser good, because the immediate good, and therefore acts out of ignorance and not by knowledge. The Socratic virtue of the art of measurement is precisely that of distinguishing between that which appears desirable and that which is really desirable, and that means a discrimination between ends.

A moral act, then, for a human being, is an act in which human intelligence is operating in its complete form, an act for which the person assumes full responsibility, an act performed in full knowledge of what it is all about, and such an act is realized only when the chosen means are prompted by chosen ends. To be moral is to know what you are doing, and to be responsible for what you are doing, because you know where you are going, why you are going there and how you are to get there. It is to live the life that is worthy of a human being to live because he is capable of living it. And this is the life of human intelligence. Man's obligation to be intelligent, which simply means to be a man, a human being, is also his obligation to be moral, which in turn means to indicate by his actions that he is aware of himself as a man.

Thus far I have but indicated that the Socratic conception of virtue as knowledge of lesser and greater makes moral action a function of human intelligence, and therefore makes the science of behavior, psychology, the basis of the moral, or good, life. It now remains to see whether the identification of morality with intelligence is tenable. The evidences to be considered are fourfold: (1) that the view is in harmony not only with moral theory in general, but even with traditional or authoritarian morality; (2) that it is in keeping with the fact that morality is an exclusively human concept and even then only under certain circumstances; (3) that it is confirmed by common experience; and (4) that it is the only view that promises to fulfil the function of any moral principle.

(1) That moral action is impossible without critical knowledge, without the art of measurement, is recognized both by moral philosophy and moral tradition. There is a difference, however, even among moral philosophers, as to what it is that critical intelligence is to be applied to. For Plato, as has already been indicated, the knowledge of good and evil is the knowledge of magnitudes, resulting in the triumph of the greater over the lesser. In Aristotle, who identifies virtue with happiness, in that happiness is the supreme good because it is the end for which all else is desired, happiness is stated to consist in man's power to live the rational life in keeping with perfect virtue, and perfect virtue is defined as the life of moderation or the avoidance of excess and defect. The difference between Plato and Aristotle is that whereas for the former critical intelligence *is* virtue, for the latter critical intelligence *can* be virtue. In other words, the intelligent man of Plato can do no evil, whereas the intelligent person of Aristotle may do evil. In this respect Aristotle is more in the keeping with what we call practical common sense

than Plato, and to that extent Aristotle is probably also wrong. Spinoza, verging on the mystical in his pantheism, nevertheless conceives of virtue to lie in man's intellectual power, reason, which leads to knowledge, to understanding of ourselves. Virtue, he defines, as "acting, living, and preserving our being as reason directs," and "reason desires nothing but to understand, nor does it adjudge anything to be profitable to itself excepting what conduces to understanding." The absolute virtue of the mind is to understand, and only in so far as it understands "can it be absolutely said to act in conformity with virtue." Kant opens his treatise on "The Fundamental Principles of the Metaphysics of Ethics" with the proclamation that "It is impossible to conceive of anything anywhere in the world or even anywhere out of it that can without qualification be called good, except a Good Will." And this good will is good "not because of what it causes or accomplishes, not because of its usefulness in the attainment of some set purpose, but alone because of the willing, that is to say, of itself." But this good will is impossible without reason, in that reason is absolutely indispensable to it, because the good will itself consists in the conception of a law, and this conception is possibly only in a rational being. This law, the conception of which is the supreme good which we call moral, and which serves as principle for the will, Kant formulates as follows: "I am never to act otherwise than *so that I could at the same time will that my maxim should become a universal law.*"

Now, whatever the differences to be found among the moral philosophers, on one thing there is agreement, and that is that human intelligence is the source of moral action, that to act morally is to know what you are doing, which consists of knowing the ends being pursued, and controlling the action to conform to the end. The person planning to rob a bank does not know what he is doing because he has not stopped to examine the end he is pursuing.

Like moral theory, the moral injunctions of the religions, which together constitute the moral tradition of mankind, place moral action in the realm of knowledge. They hold, in agreement with moral theory, that a moral act is an act performed in full consciousness of the end to be achieved. But the end of moral tradition is a legal injunction of superhuman origin to which man is to give his consent and follow without question. By his own intelligence man can not discover his good, but by his intelligence he can learn to know the law, make it his own and demonstrate to himself that to obey it is wisdom, to disregard it is folly. Human reason operates for human good only when it is used to justify God's ways with man. Far apart, then, as moral theory is from moral tradition, both nevertheless posit knowledge as the basis of morality.

(2) When we examine the question as to why it is that no moral significance is attached to the actions of animals, infants, feeble-minded, insane, and even to normal human beings under certain conditions of stress, the answer again is critical intelligence. A man in a rage is not responsible for his actions because he is off his head, does not know what he is doing, although whatever he is doing may be well done. The person with a homicidal mania may show uncanny shrewdness in carrying out his purpose, but he is irresponsible because his purpose is insane. The infant and animal are judged to be neither moral nor immoral, but amoral, because we do not consider them capable of consciously controlled activity, and they are therefore irresponsible. The criterion, then, that we use in making moral judgments

in ordinary daily contacts is then that of critical intelligence: an act being judged moral only when it produces the impression that the acting agent is fully aware of what he is about.

(3) A further piece of evidence favoring the identification of moral action with the art of measurement is the use of the term character as a designation of personality. What is it that distinguishes between the weak and the strong character? The drug addict is a weak character, obviously so because he is ruled by his appetite. He may show no end of ingenuity in obtaining his drug, yet he is a weakling because he fails to control himself by controlling the end. Again, the concern here is not as to the reasons for his pursuit of an uncritical end, the point simply is that the judgment of weakness, with its implication of immorality, or perhaps amorality, is the value placed upon an act that does not involve the functioning in full of what human intelligence is capable. Weakness is sickness, and sickness is a lesser form of health. And when the lesser predominates over the greater in behavior, no matter what the cause, the character suffers, like a person with a physical ailment.

(4) But the final test of the validity of the psychological conception of morality as action in conformity with human intelligence must be in the objective of all moral precepts and principles, namely, the bringing about of a stable, harmonious society. And it can be demonstrated that the conception here presented not only promises to bring about an ordered society, but that it is the one indispensible condition for such a society. This can best be done by seeing whether the ills of society are not directly traceable to the operation of the very principles of moral tradition that are proposed for their cure, because these principles violate the criteria set down at the outset as the axioms of moral truth.

That society is sick, and that traditional moral precepts have failed to cure it, is not denied by even the most uncritical and fanatical supporter of supernaturalism in moral thought. But he will deny that the failure demonstrates the falsehood of his principles, but rather indicates the obstinacy and natural depravity of man. According to the moralist, what is needed is not a change of principles, but bigger and better enforcement of them, that is, more authority for the authoritarian. But this attitude violates all four axioms, in that a valid principle, that is, a principle derived from a material, does not have to be forced upon that material, because it already obeys it as the substance of its being. The fact, then, that a moral principle has to be defended, in other words, rationalized, is an indication that it is a false principle, and that is the reason why it calls for force to be put in operation. And the application of such an arbitrary principle to a material by force can only produce a distortion of the material. Besides, if a principle is concocted out of pure air, the realm of that principle becomes the playground for any one attracted to it, with the result that a horde of contradictory principles arises each of which is to be established as superior to the rest, and while the physicians quarrel the patient is passing out. The ailments of society are therefore implanted and aggravated by the medicines that are prescribed to cure them.

Another count against traditionalism is that it defines virtue, as did Protagoras, by enumerating the virtues, and calls this enumeration knowledge. It calls upon human beings to be honest, but does not define honesty, to be truthful, without defining truth, with the result that any one particular virtue becomes anything one finds convenient to

practice, just so long as he attaches the right name to it, and a label becomes a sanction for a practice, and pretty words substitutes for works. Thus the delusion arises that giving consent to a phrase transforms one into whatever the phrase represents, because that which the phrase represents, whatever it may be, or is supposed to be, is virtue. The fundamental question of morality, namely, that if human beings are to be taught to practice virtue it is necessary to ascertain its nature, traditionalism ignores.

The conception of moral action as critical intelligence, on the other hand, begins with a definition, which is the first step in any scientific procedure, and the definition itself is scientific in that it consists of a principle deduced from the material to which it is to be applied. It states what human action can be, rather than what it should, ought or must be. Since it defines virtue in terms of human nature it is consistent with human nature, and therefore true. Such a principle human beings can violate only by not living up to it, and if they fail to live up to it, it is because of ignorance, not out of obstinacy due to depravity. According to this principle, what human beings need in order to be virtuous is instruction rather than compulsion. A virtuous human being is one who lives as a human being can live because that is his nature. From this standpoint a good man is no different from a good potato. A good potato is one that adheres to the nature of a potato, that is all that a potato can be, that lives up to "potatoness." A poor human being is, again, like a poor potato, a potato that is not everything that we know a potato can be, that falls short of being a potato in its fullness. Morality as human intelligence thus obeys the criteria of scientific truth, namely, it is consistent with the facts, with the human material from which it is derived. As such it coordinates, orders and harmonizes human beings in their interrelationships, that is, socially, since in any coordinated whole a part that functions in a manner true to itself is also acting in a manner true to every other part, and therefore true to the whole.

ADAPTATIONIST NAÏVETÉ

By W. L. McATEE
BIOLOGICAL SURVEY, U. S. DEPARTMENT OF AGRICULTURE

WRITINGS on adaptations, especially those on protective coloration, embody more fantasy than has been regarded as tolerable in any other branch of biological literature. Well known among such fancies is that a certain butterfly pupa, appearing to show a glistening drop of its own blood, is protected by this subterfuge suggesting to possible predators that the pupa has already been attacked and abandoned as unpalatable. Another is that caterpillars having "eye-spots" terrify foes by their resemblance to snakes. More ambitious in the same direction is the speculation that markings on the side of the inflated head of a lantern-fly suggest an alligator and thus frighten the insect's enemies. The first of these guesses ignores the universal phenomenon that evidences of attack stimulate further aggression. Disabled creatures are fair game for predators, even of types that would not attack them in sound condition. The fate of the wounded member of a pack or of the obviously pecked bird in a flock are familiar proofs that wounds are a liability. The snake- and alligator-resemblance fantasies must be relegated to the sphere of pure invention, because the ordinary natural enemies of creatures so small as the insects concerned can have no impressions as to the appearance and powers of snakes and alligators. All the illustrations cited lean heavily on traits of animal psychology that are assumed, not known, to exist. They are imaginings and, if naïveté, are of an artificial sort scarcely creditable to their inventors.

There is unfeigned naïveté, however, and in the same field it produces speculations, which, though parallel to those cited, can be recognized as far-fetched even by persons who have given no special thought to adaptation hypotheses. For the present purpose such speculations are exemplified by quotations from the Journal of the New England writer, Henry D. Thoreau. This is done with no intent of holding Thoreau up to scorn, for he is admired for his contempt for worldly possessions, his love of nature and his poetic views on natural phenomena. It is of interest that the suggestions here quoted and numerous others in his Journal considerably antedate those of Belt, Wallace and Darwin —authors usually regarded as founders of the protective adaptation school.

Some of the examples attribute protection to harmonization with comparatively recent man-made environment—something that could not have been produced adaptively, that is, as a result of age-long natural selection.

BITTERN

I took out my glass to look for ducks, and my companion, seeing what I had, and asking if it was not a stake-driver, I suffered my glass at last to rest on it, and I was much surprised to find that it was a stake-driver after all. The bird stood in shallow water near a tussock, perfectly still, with its long bill pointed upwards in the same direction with its body and neck, so as perfectly to resemble a stake aslant. If the bill had made an angle with the neck it would have been betrayed at once. Its resource evidently was to rely on its form and color and immobility solely for its concealment. This was its instinct, whether it implies any conscious artifice or not. I watched it for fifteen minutes, and at length it relaxed its muscles and changed its attitude, and I observed a slight motion; and soon after, when I moved toward it, it flew. It resembled more a piece of a rail than anything else—more than anything that would have been seen here before

the white man came. It is a question whether the bird consciously cooperates in each instance with its Maker, who contrived this concealment. I can never believe that this resemblance is a mere coincidence, not designed to answer this very end—which it does answer so perfectly and usefully (pp. 69–70). [The resemblance is to a stake or a piece of rail.]

VESPER SPARROW

He sits on some gray perch like himself, on a stake, perchance, in the midst of the field, and you can hardly see him against the ploughed ground (p. 288).

TREE SPARROW

These birds, though they have bright brown and buff backs, hop about amid the little inequalities of the pasture almost unnoticed, such is their color and so humble are they (p. 297). [Resemblances to a stake, ploughed ground and pasture.]

Another set of excerpts attributes protection to sounds like those of the environment—a step further than most of the present-day adaptationists have gone.

AMERICAN MERGANSER

Now and then they seemed to see or hear or smell us, and uttered a low note of alarm, something like the note of a tree-toad, but very faint, or perhaps a little more wiry and like that of pigeons, but the sleepers hardly lifted their heads for it. How fit that this note of alarm should be made to resemble the croaking of a frog and so not betray them to the gunners! (p. 25.)

BITTERN

After the warm weather has come, both morning and evening you hear the bittern pumping in the fens. It does not sound loud near at hand, and it is remarkable that it should be heard so far. Perhaps it is pitched on a favorable key. It is not a call to its mate? Methinks that in the resemblance of this note to rural sounds, to sounds made by farmers, the protection, the security, of the bird is designed (pp. 65–66). [Farm environment is too recent to have any effect by "selection."]

PASSENGER PIGEON

I scare pigeons from Hubbard's oaks beyond. How like the creaking of trees the slight sounds they make! Thus they are concealed. Not only their *prating* or *quivet* is like a sharp creak, but I heard a sound from them like a dull grating or cracking of bough on bough (pp. 113–114). [Authors in general refer to overwhelming conspicuousness of passenger pigeons.]

Such speculations are best termed poetic fancies, but they are not more out of touch with reality than many of the protective adaptation effusions of much more recent authors. As to Thoreau, it was said:

He never became in any respect an expert ornithologist, and some of the reasons are not far to seek. He was too intent on becoming an expert analogist, for one thing. It better suited his genius to trace some analogy between the soaring hawk and his own thoughts than to make a scientific study of the bird.[1]

[1] Henry D. Thoreau, "Notes on New England Birds." Excerpts from his journal, arranged and edited by Francis H. Allen, 452 pp., 8 pls., 1 map, 1910.

An analogist, not an analyst was he, but it may be said that his naïveté was unfeigned and unavoidable, while that of modern marvellers, conscious of the just criticism of their course, is neither. Unique wonders here and there (as the leaf fishes, the shadowed toad, the shadowless grasshopper, etc., of 1938) are publicized without admission that living in the same environments with them and getting along just as well are other creatures that are not similarly "protected." The "adaptations" are thereby shown to be unnecessary to survival in that environment, hence they can not have been produced as postulated by the natural selection theory.

The elaborately adapted are advanced specialists. Like human specialists, who have been defined as those who progressively learn more and more about less and less, these excessively specialized creatures are more and more "adapted" to a less and less prevalent moiety of the environment. The more extremely they are specialized, the more restricted is the

fraction of the highly varied environment in which they can live. Thus they can not be increasing in numbers, hence do not answer to the criterion of a successful species under natural selection theory. They are following the course of all highly specialized creatures, that is, to senescence and extinction. The process, like all evolution, is orthogenetic and natural selection has nothing to do with it. Natural selection by definition is survival of the fittest, but beneficiaries of a process of survival of the fittest could not become extinct. It is stultification to assert that the mainspring of evolution as it evidently occurred is survival of the fittest.

In every geological age, the habitable world has been occupied by animals in variety. They were fit in their time, they were adapted, just as much as those of to-day, but they are gone. Among them may be instanced forms undoubtedly superior in their way to anything that exists to-day, as the great aquatic and terrestrial predacious birds (*Hesperornis, Diatryma*), the predacious dinosaur (*Tyrannosaurus*) that animated battering ram, *Triceratops*, the marine *Plesiosaurus*, the imperial elephant, giant bisons and elks, cockroaches and dragonflies, the saber-toothed tigers, and so on. In their lines these animals have never been surpassed; they did not perish from competition.

There have been wonders both great and small in every age, and to hail creatures of to-day as the fittest for their particular types of environment shows lamentable lack of perspective. As a rule, indeed, it seems that the great are gone, and only mediocrities remain. What would the adaptationists have done in an earlier age? Judging from their present behavior, they would have exploded with enthusiasm. In that fortunate event, we should not have to worry about them now, but it is only a dream from which we awake to realize that they are here and in some instances very active.

Naïvely they dote on marvels and the adulation they extend entitles the wonders to be known as "omeomys" and their idolaters as the "ohmy" school. It is somewhat surprising that this school flourishes most in a race that particularly prides itself upon poise. Perhaps the indulgence may be psychoanalyzed as a welcome release from that pose—a relaxation made respectable by association with a few big names.

SCIENCE AND THE "FOUNDING FATHERS"

By Professor JOHN WM. OLIVER
UNIVERSITY OF PITTSBURGH

THIS year, 1939, marks the sesqui-centennial of the establishment of our Federal Government. Once again, it will be appropriate for all those who want to call upon President Washington, or the members of his cabinet, or those who sat in those first sessions of Congress, for support in proving any one of a dozen pet theories that are abroad in the land. Such phrases as "from the very foundation of our government"; "The Founding Fathers stood for . . ."; "Washington and his colleagues demanded . . ."; "in the beginning our government insisted that . . ."; and others of similar note will be drummed upon until one wearies in hearing them.

But is it worth while for those interested in science to turn their attention back to the days of the "Founding Fathers"? Did they know or care enough about science to be concerned with it? Were they interested only in the political set-up of a new government? Let us see. A review of those first years reveals a surprising amount of interest on the part of the "Founding Fathers" in science, invention and technology.

President Washington, in his first Annual Address to Congress, delivered on January 8, 1790, emphasized, above everything else, the encouragement of agriculture, commerce and manufacturing by all proper means. He went on to say:

> I cannot forbear intimating to you the expediency of giving effectual encouragement to the introduction of new and useful inventions from abroad, and to the exertions of skill and genius in producing them at home. . . . Nor am I less persuaded that there is nothing which can better deserve your patronage than the promotion of science. . . .[1]

[1] Richardson's "Messages and Papers of the Presidents," I, 58.

Both the House and Senate received the President's message most cordially. Within a few days they sent a favorable reply, declaring that "the introduction of new and useful inventions from abroad, and the exertion of skill and genius in producing them at home . . . shall receive such early attention as their respective importance requires."[2]

When Washington called upon the first Congress of the United States, and urged its members to encourage agriculture and all new inventions; and to promote science, he was expressing a hope that was already widely current throughout the young republic.

The period following the close of the Revolutionary War down to the establishment of the Federal Government is an important one in the early history of applied science and technology. During the years of the war, commerce had been interrupted, and the colonies had been cut off from the rest of the world. The American people had to depend upon themselves. This was true not only of war supplies, but also for the necessary articles needed in daily use. As a result, individual states had given all possible encouragement to their citizens during the war and the years immediately following. In 1783, Massachusetts built a glass factory with the proceeds of £3,000 of lottery money. In 1785 the South Carolina Agricultural Society offered medals for the making of oil from cotton, peanuts, sunflowers, sesame and other seeds. The same year, 1785 saw the birth of the Philadelphia Society for the Promotion of Agriculture, and a similar society in Massachusetts. In 1787, the manufacture of glass had been started in Massachusetts, New York and New Jersey. And in this

[2] *Annals of Congress*, I, 934.

same year, the Pennsylvania Society for the Encouragement of Manufactures was organized. Before the decade of the 1790's had closed, salt was being successfully manufactured in western New York, morocco and colored leathers were being made in Philadelphia; Paul Revere had established an iron foundry, and John Hewson was printing calico and linen in Pennsylvania. In 1789, a French observer had noted that the farmer and artisan in America had more work to do than they could get done. The scarcity of labor made for high wages, and to supply the want of labor and time, the early Americans were forced to invent—to think out new ways of augmenting their efficiency.

First Patent Law

Washington's plea to Congress, asking for their support in encouraging the introduction of new and useful inventions and to lend their patronage to the promotion of science, was favorably received. A simple, workable patent law was one of the first needs. Soon after Washington's inauguration in April, 1789, Congress took up the question of establishing a new patent system. The debates continued, irregularly for almost a year. Early in 1790, Colonel John Stevens presented a petition to Congress that served as the basis of the new patent law. In April of that year, the act was passed and signed by President Washington. The law was short, simple and easily administered. Anything could be patented if it could be classified as "any useful art, manufacture, engine, machine, or device, or any improvement therein not before known."[3]

It was fortunate that Thomas Jefferson, Secretary of State in Washington's cabinet, was the man charged with the responsibility of administering the first patent law. Any project of a scientific, technical nature appealed to him. Jefferson possessed a most versatile mind. He was the best-suited man in this country for the new job. His enthusiasm for science and industry was not equalled by any other person of his day. He never overlooked an opportunity to promote a scientific inquiry or to add a new fact to his storehouse of technical knowledge. He was constantly encouraging the introduction of new devices and the application of science to everyday living. He had written in one of his numerous letters, "I have wished to see chemistry applied to domestic objects, to malting, to brewing, making cider, bread, butter, cheese, soap, and the incubation of eggs." He had already designed a new moldboard for a plow, scientifically constructed according to mathematical principles.

Jefferson had a profound faith in the inventive ability of his fellow Americans. He was sure that they were the equal in skill, ingenuity and inventiveness of any European. In 1785, he had been asked by an American father to advise him whether Rome or Geneva offered the best educational opportunities for his son. Jefferson's reply sounds almost like a rebuke. He wrote, "But why send an American youth to Europe for an education? What are the objects of a useful American education?" He went on to point out that emphasis in "our day" should be placed on agriculture, chemistry, botany—subjects that would be useful to an American.[4]

The inventive geniuses of the young republic were quick to take advantage of the new patent law. Upwards of fifty patents were issued under the act of 1790. New mechanical devices came so fast that the department of state was swamped with applications. Jefferson insisted on examining personally every application

[3] *Journal of The Patent Society*, Centennial Number, July, 1936, Vol. XVIII, No. 7, p. 63.

[4] "Jefferson's Writings," Memorial Edition V, 186.

that was filed. The work became so heavy that not only Jefferson, but other department heads found it impossible to hear and examine all applications. Accordingly, the act of 1790 was repeated, and a second act passed in 1793.[5] This act provided for the granting of patents in routine fashion, to any one who took an oath testifying to the originality of his device and paid the sum of thirty dollars. No one but a citizen of the United States could receive a patent. This act remained in force until 1836, when the Patent Office was reorganized with a rigorous system for the examination of all claims, in order to prevent duplication.

From the very beginning of our Federal Government, the protection of property rights of inventors has been a definite American policy. In Europe, invention privileges had been granted by the rulers. Over there, the privileges emanated from and were bestowed by the Crown. In America, however, the theory was defended that invention was a right, not a privilege. And the founders of the government proclaimed the patent laws as the agent by which they enjoyed those rights. The policy of this country from the very beginning has been to encourage useful arts. This policy has been a powerful factor in bringing about the innumerable inventions that have contributed to the greatness of American science and industry and to the comfort of the American people.

Hamilton's Report

That first American Congress, sitting in New York, devoted much time and attention to encouraging useful arts and infant industries. They were not unmindful of the part that American manufactures had played during the Revolutionary days. On January 15, 1790, the House of Representatives called upon Alexander Hamilton, Secretary of the Treasury, to prepare a "Report" on the subject of manufacturing. They asked particularly for suggestions looking toward the promotion of those industries that would render the United States independent of foreign nations.[6] Hamilton submitted his "Report" late in the year 1791.[7] It has rightly been called one of the great documents of early American history.

Hamilton surveyed the current status of the manufacturing conditions, and proposed means whereby they could be aided by proper encouragement. The developments of new industries and manufacturing would, he said, promote the division of labor, the use of machinery and stimulate new inventions. All this would furnish work for the unemployed. Increased employment would insure a steady demand for the surplus products of the soil; and animals, plants and minerals would acquire a utility which they had not heretofore possessed. Hamilton proposed to encourage these new industries by setting up a protective tariff. But even more important was his proposal to encourage new inventions and new discoveries here at home. His "Report" was given the widest possible publicity. One immediate result was that the individual states got busy and awarded special bounties for new industries and granted special tax exemptions to others. Prizes were offered by numerous societies that had been formed to stimulate domestic production.

Origin of Manifest Destiny

The founders of the young republic were keenly alive to the economic and scientific possibilities in this New World. Jedediah Morse's book, "American Geography," which had just been printed (1789), was bristling with the idea of manifest destiny for this stirring young

[5] *Annals*, Appendix, III, 1431.

[6] *Annals*, I, 1058.

[7] *Annals*, III, Appendix, 971–1034.

nation. One section of that epochal little volume was devoted to the Western Country—the trans-Allegheny region. He described the seat of empire as ever traveling from east to west. The last and broadest seat of that empire would, in his opinion, be in America. Here the conditions were suitable for the highest degree of the sciences and arts. He declared that in the United States, genius, "aided by all the improvements of former ages, is to be exerted in humanizing mankind—in expanding and enriching their minds . . . with philosophical knowledge."[8]

The most philosophical as well as the most practical scientist of this period was, of course, Benjamin Franklin. True, he died (1790) just as the new government was being established, but during his long life he had advanced the cause of science, practical and theoretical, more than any other person in American history. His work in physics, meteorology, mathematics, geology, chemistry, medicine and natural history places him among the great men of science for all time. As he was approaching the end of his life, he declared in a letter to Priestley that his chief regret was that he had been born too soon. He sensed a great scientific future for young America. The time would come, he prophesied, when a rigid system of sanitation would be enforced. Scientific farming would be introduced, and with the use of preventive medicines, man's span of life would be lengthened at pleasure, even beyond the ante-diluvian standard.[9]

Morse, Franklin and the "Founding Fathers" had good reason for feeling so confident of America's scientific future. Already, a number of small, but promising industrial and manufacturing developments were well under way. When the new Ship of State was launched in 1789–90, there were paper mills, glass plants, potteries, iron foundries and forges already in operation. The mineral resources of the young nation were yet unknown. Iron ore was abundant for the then simple needs. Some coal, copper, lead, gold, silver and sulfur had been extracted. Fisheries and shipyards were sources of great wealth. James Wodehouse and his scientific friends were busy organizing the first Chemical Society in the United States in 1792. One of its objects was to acquaint the public with the various uses of minerals and to encourage the manufacture of pottery.[10]

This same year 1792, a professorship in natural history, chemistry and agriculture was established at Columbia University, at an annual salary of 200 pounds. Two years later, 1794, the famous Dr. Joseph Priestley arrived in this country, and lent his aid to the enthusiastic young scientists of America. David Rittenhouse, whom Jefferson declared to be "the greatest mechanical genius of the world," was rewarded by our first President in being appointed the first Director of the Mint. By 1792, Mathew Carey's book, "American Museum" had, due to its popularity in promoting home industries, run through twelve editions. During this same period, Tench Coxe was writing to James Madison, a member of Congress, urging that an appropriation of a million acres of western land be set aside to provide funds to reward the introduction of machinery, invention, art and other projects of similar nature.

The "Founding Fathers" during those first years when laying the structure of a new government were equally concerned in pointing the way that applied science,

[8] J. C. Parish, "The Emergence of Manifest Destiny," p. 16. Los Angeles, 1932.

[9] N. G. Goodman, "The Ingenious Doctor Franklin," 11, 12. 1931.

[10] In 1795, Wodehouse became professor of chemistry in the University of Pennsylvania; two years later he published the "Young Chemists Pocket Companion," the first chemistry laboratory guide to be published in the United States.

inventions and industrial progress should develop. Now that political independence had been won, they were equally anxious to establish economic independence. They reflected the universal optimism of that day, which told of the unlimited possibilities that lay ahead for all who were willing to take a chance. Washington, Jefferson, Hamilton, Franklin, Coxe and others believed strongly in harnessing the forces of nature to the chariot of human progress by means of applied science and technology. Over and over again, one reads statements like these, sprinkled among the weighty political discussions: "the prosperity of the United States is the primary object of our deliberations"; "manufactures and useful inventions are our first needs"; "I, (Washington) cannot forbear intimating to you the expediency of giving . . . encouragement to the introduction of new and useful inventions, . . . and to the exertion of skill and genius in producing them. . . ." And in addressing his fourth Congress, Washington reviewed the great progress made in agriculture, commerce and manufacturing, declaring," with resources fully adequate to our present exigencies . . . with government founded upon the general principle of national liberty, with mild and wholesome laws—is it too much to say that our country exhibits a spectacle of national happiness never surpassed, if ever before equalled?"[11]

Such words sound like a scientific benediction from the Father of Our Country! Here was a young nation whose people had for a century and a half been trained to provide their own needs, and to supply their own wants. Now, with those "mild and wholesome laws" which President Washington promised as an incentive to go forward, the next century and a half was to witness an advance in the field of science and technology, the like of which the world had never seen.

[11] Richardson's "Messages and Papers of the Presidents," I, 176.

THE WHALE SHARK IN THE CARIBBEAN SEA AND THE GULF OF MEXICO

By Dr. E. W. GUDGER

BIBLIOGRAPHER, THE AMERICAN MUSEUM OF NATURAL HISTORY

In a comprehensive paper[1] covering twenty-two years' work on the geographical distribution of the whale shark, I have located every known specimen as of December 31, 1934. In this article may be found the scanty data for the Caribbean—and all at second and third hand. While for the Gulf, excepting second- and third-hand reports of the occurrence of *Rhineodon* in the Yucatan Channel, and numerous records (made mainly by myself) of its occurrence in the Strait of Florida (Florida coast and off Havana), all was blank. Even lacking scientific evidence, one could still be sure that this great fish was found in the Caribbean and Gulf; for its relative abundance in the Strait of Florida, explainable only on the basis of the manner of distribution, showed that it must be found in the Caribbean and the Gulf. But what was necessary was direct evidence. This I now have. It will be set out in chronological order.

Rhineodon in the Caribbean Sea

Report No. I.—In 1937, I published a short note[2] on a whale shark impaled on the bow of a steamer on the run from Cristobal, C. Z., to Cartagena, Colombia. This report was made possible through the kindness of Chief Officer A. E. Richards of the vessel concerned, who came to my office in the Museum and described the shark and its capture.

No. II.—For information as to another occurrence of *Rhineodon* in Caribbean waters, I have to thank Mr. Fred Fletcher, a newspaper man, who sent me a clipping describing the curious behavior of a great shark around the steamer *Colombia* of the Colombian Steamship Company in the harbor of St. Marc, Haiti, March 24, 1937. My letter to the company asking for information came to the attention of Mr. C. H. C. Pearsall (president of the steamship company) who fortunately was on the steamer at the time and who has kindly given me full details.

The great shark hung around the steamer in the early evening while she was loading bananas under strong electric lights. A number of the crew got out firearms and shot at it, but from its 3- or 4-inch thick armor-like skin the bullets glanced harmlessly. Boys in small boats were alarmed by the familiarity of the shark and hurried aboard ship, letting their skiffs drift away. The fish came up under the companionway one time, raised its head and dislodged the platform at the bottom of the ladder. Occasionally it bumped into the ship, the impact being readily noticeable. It stayed around the ship about two hours, but would not take baited hooks (no harpoon was available). It being night, no photograph could be made.

I asked Mr. Pearsall if this could be a large tiger shark. He said that he knows the tiger and that it was not, and gave me a description of this shark (estimated to be about 25 feet long), which showed conclusively that the fish that played around the ship was a *Rhineodon*. Later when I sent him a copy of my article[3] on the whale shark captured off Long Island in 1935, which fortunately he had seen at Islip, Mr. Pearsall unhesitatingly identified the St. Marc fish as identical with the Islip specimen.

[1] *Proc. Zool. Soc. London* (for 1934), 1935, pt. 4, 863–893, pl.

[2] *Copeia*, April 10, 1937.

[3] *Nat. Hist.*, 37: 159–166, 7 figs., 1936.

Here then are two proofs of the occurrence of the whale shark in the Caribbean. This lends credence to the second- and third-hand accounts previously adduced.

Sharks in the Gulf of Mexico

The eight accounts now to be quoted have all come to me through the courtesy of the U. S. Hydrographic Office. They are the responses to a brief article (with a figure of the fish) published in the *Hydrographic Bulletin* in 1934, and to the later publication therein of various notes on reports by ships' officers of whale sharks seen in various regions. It is a pleasure to make acknowledgment of the generous help of the Hydrographic Office for these and other data.

Reports Nos. I and II.—Mr. S. H. Reid, chief officer of the S.S. *Dungannon,* of the Texas Company, reports that on August 10, 1933, while on a trip from New York to Port Arthur, Texas, in Lat. 28° 00′ N. and Long. 90° 20′ W., the ship passed close to a school of 6 large sharks moving slowly about. Five days later (August 15) on the return voyage from Port Arthur about 2 P.M., the ship being approximately in the same position, Mr. Reid saw what was apparently the same school of 6 specimens. They were entirely unafraid, indeed one left the school and came alongside the ship and then went back to the group.

Mr. Reid's description is so definite as to tail, shape of head, coloration, etc., that it assures me that these were whale sharks. He estimates their lengths at 40 to 50 feet. They are the only ones he has ever seen or known of in the Gulf of Mexico.

No. III.—Mr. E. Kvande, second officer of the S.S. *Gulfoil* of the Gulf Refining Company, reports that about 2 P.M. on May 14, 1935, his ship passed a school of great sharks in Lat. 27° 31′ N., and Long. 89° 47′ W., on a voyage from Port Arthur to Philadelphia. The day was clear and the sea relatively quiet. The fish appeared close on the port bow, and the nearest had to steer off to clear the ship, passing leisurely at a distance of about 40 feet. Twelve were counted, swimming near the surface, each with back fin and upper part of tail above water. The two nearest were estimated to be 25 to 30 feet long. Two solitary fish led the school, eight swam in fairly defined pairs, and two stragglers brought up the rear. Mr. Kvande correctly reports the shape of the head, white spots on head, fins and tail, and the checkerboard squares with white spots.

No. IV.—This occurrence is reported by Captain Aug. Randall, of the S.S. *John D. Archbold,* of the Standard Oil Company of New Jersey, as noted on May 24, 1937, in Lat. 26° 02′ N., and Long. 88° 21′ W. The school was seen at 11:45 A.M. and was estimated to be made up of about 30 fish. They were not disturbed by the ship's passing them at a distance (to the nearest) of about 20 feet but swam lazily along and "did not appear to be going anywhere." The sky was clear and the sea smooth and the fish were readily observed. Captain Randall's description of the make-up and coloration of the sharks leaves no doubt that they were whale sharks. They appeared to be about 14 feet long, and hence were young and immature specimens. Their small size leads to the conclusion that the whale shark breeds in the Gulf of Mexico.

No. V.—Mr. V. D. Parsons, second officer of the S.S. *Albert E. Watts,* writes that on May 26, 1937, at 4 P.M., his vessel passed 6 whale sharks in Lat. 26° 48′ N., and Long. 88° 35′ W. These seen at a distance were thought to be whales or blackfish, but, when approached more closely, were seen to be neither. The position and shape of the mouth, the fins and the coloration (checkerboard, etc.) corresponded with the figure of *Rhineodon* in the *Bulletin.* The fish were not afraid, though the vessel passed so closely that her wash broke over them. Mr. Par-

sons reports that had the nearest one been in the ship's path, it would have been rammed, so sluggish was its motion. The fish were about 30 feet long.

Nos. VI and VII.—Both these accounts are reported by Captain Edw. J. Niblett, of the British S.S. *Eskdene*. The sharks were seen on different trips in 1937.

On a voyage from the River Plate to Houston, Texas, in May, 1937, the ship passed quite close to four of these fish in Lat. 27° 10′ N. and Long. 89° 50′ W. They were in pairs about 40 feet apart, of unequal size—the largest being 25 to 30 feet long. They too were so sluggish that they made no attempt to get away from the steamer. The checkerboard markings were distinct on all and corresponded with those shown in the *Bulletin* article.

On her next voyage (from Corner Brook, N. F., to Beaumont, Texas) on July 17, 1937, in Lat. 27° 20′ N. and Long. 89° 40′ W. (in almost the same position as before) Chief Officer G. Stronghair noticed a great shark, identical with those seen before and with the figure in the *Bulletin*.

No. VIII.—Last of all, Officer H. S. Brewster, of the Gulf Oil S.S. *Gulfbelle* reports that on May 9, 1938, at 10:00 A.M., his vessel sighted three whale sharks in Lat. 26° 15′ N. and Long. 81° 58′ W. They were close to the ship, swimming just awash slowly in a southerly direction. These fish were about eighteen or twenty feet long and had wide heads. Their color was black with round white spots. They were surely whale sharks.

Data from the Gulf of Mexico

The reader has noted that the observations were made on trips to or from the eastern Texas oil ports. And to bring more sharply and clearly the matters set out above, the data are synopsized in Table I.

From the table the reader finds that eight observations are recorded from six ships, two each from two different ships—the two observations from the *Dungannon* in the same locality. The dates run from May 8 to August 15, and the years are 1933, '35, '37, '38. The fishes counted are 38 and those estimated are 30—a total of 68. Surely it may be said that at least 50 whale sharks were seen in the Gulf of Mexico from which not a single specimen has ever been recorded before. Last of all and most notable is the close contiguity of the places in which these great sharks were seen. This deserves special attention.

It is significant that these reports come from (oil?) ships plying to and from east Texas oil ports through the Strait of Florida to or from the eastern ports of North America. The one exception is the *Eskdene* from the River Plate to Houston. She must surely have come through the Caribbean. The latitudes and longitudes have been plotted on Chart I that it may be seen how close to each other these positions are.

These localities are strung out in a northwest-southeast direction over a distance of approximately 175 miles. Their east and west spread is approximately 120 miles. Finding a center, they are all

TABLE I

Rept. No.	Steamer	Date	Voyage	No. of sharks	North Latitude	West Longitude
I	*Dungannon*	Aug. 10, '33	to Port Arthur	6	28° 00′	90° 20′
II	*Dungannon*	Aug. 15, '33	from Pt. Arthur	6	28° 00′	90° 20′
III	*Gulfoil*	May 14, '35	from Pt. Arthur	12	27° 31′	89° 47′
IV	*Archbold*	May 24, '37	....	c. 30	26° 02′	88° 21′
V	*Watts*	May 26, '37	....	6	26° 48′	88° 35′
VI	*Eskdene*	May —, '37	to Houston	4	27° 10′	89° 50′
VII	*Eskdene*	July 17, '37	to Beaumont	1	27° 20′	89° 46′
VIII	*Gulfbelle*	May 8, '38	....	3	26° 15′	86° 58′

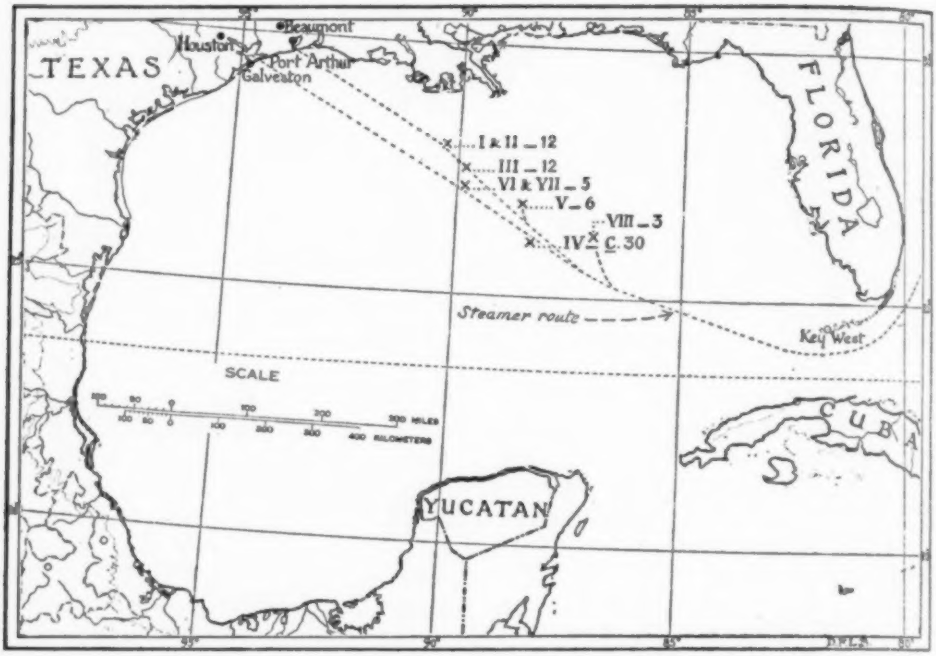


CHART I. CHART SHOWING THE LOCALITIES OF EIGHT GROUPS OF WHALE SHARKS OBSERVED IN THE GULF OF MEXICO

THE LOCALITIES ARE MARKED THUS—X. THE ROMAN NUMERALS INDICATE THE REPORTS OF OBSERVATIONS IN CHRONOLOGICAL ORDER, THOSE IN ARABIC THE NUMBER OF WHALE SHARKS SEEN FROM EACH VESSEL. THE DOTTED LINES SHOW THE STEAMER ROUTES, WHICH CONVERGE INTO ONE.

contained in a circle whose radius is 87.5 miles. Or they are all contained in a parallelogram whose height is *c.* 175 miles and whose base is *c.* 120 miles.

This is very difficult. So far as I can find there is no peculiarity of currents which might account for the gathering of whale sharks here. I have always held that *Rhineodon* was a littoral shark. In the extensive article above referred to, the 76 individuals listed had all been found at least fairly close along shore. But in the chart the nearest group was about 70 miles from land and in water 200 fathoms deep. The farthest group, No. IV, was 200 miles from the nearest land (the delta of the Mississippi River), and in water 1,250 fathoms deep.

As reported, these fishes "did not seem to be going anywhere," they were not "making a passage" but were just loafing along. Their concentration may have been due to a concentration of their food, which seems to be small fishes, squids, jellyfishes, small crustacea—probably all kinds of plankton. If this is so, it merely pushes the question back so much further. —What causes the concentration of the sharks' food in this particular region? And to this no answer can be made in the present state of our knowledge.

The things we can be sure of are that these fish were on the dates specified in the track of steamers between the eastern seaports of Texas and the Strait of Florida, and that they came under the eyes of ships' officers whose vigilance had been stimulated by the publication of the little article and of various records of occurrences of the shark in the *Hydrographic Bulletin,* and lastly that they showed no fear of the vessels and were swimming slowly along in no particular direction.

THE ORIGIN OF BIRDS

AND WHICH CAME FIRST, THE BIRD OR THE EGG?

By Dr. EDWARD L. TROXELL

PROFESSOR OF GEOLOGY, TRINITY COLLEGE, CONNECTICUT

THE age-old question—Which came first, the bird or the egg?—seems now to have an answer, thanks to studies in genetics and in evolution, and, any way you look at it, the egg wins.

Of course there are many who believe that adult birds were created *de novo;* like Adam, they were fashioned out of dust and flew away without parent or pedigree. To the scientist this belief offers no food for thought, so let us confine our inquiry to an orthodox scientific basis and see what answer comes to the problem, Egg or bird?, first.

In a study of this problem, which deals so intimately with bird-ancestry, it is inevitable that one be concerned with the origin of feathers, of flight and of other such things that seem to be so essentially a part of bird make-up.

The story of bird origin actually begins far back in geological time, but for the present purpose we shall take it up at the close of the Great Coal Period, where we see just the right climatic conditions for the beginning of the feathered folk. From many and varied evidences the geologists are aware of vast changes in the physical conditions at that time; there was increasing aridity and coldness; it was a time of mountain-making and upheaval. In the circumstance nature, it would seem, set out to devise a type of animal that could withstand the new conditions. This new creature was to be a "reptile" that would be covered with a coat of downy feathers; it would stand up on its hind legs, lift its body up off the cold ground, would have greater activity and would maintain a constant body temperature. When this was accomplished, especially when a coat of feathers was formed, the bird was created. Indeed, the moment one mentions a "reptile" with a coat of feathers one has already described a bird. It is notable that, in the last analysis, feathers, alone, are the distinctive feature of the birds; not egg-laying, for reptiles and some mammals share that with the birds; not flying, for both reptiles and mammals have learned to fly.

It is a well-established fact that birds evolved from a race of reptile-like animals which, themselves, had had a long period of evolution. Through hundreds of thousands of years, doubtless, there went on a gradual change from the scaly ancestor to the feathered bird. It would have been difficult to tell, even if one had been there, just when the change was completed; it would have been impossible to mark the point where the transition was completed in this marvelous formation of the bird, although, in theory, there was some definite point, some stage in the race history where the parent was reptilian and the next generation was avian. But it is not necessary, in making our point, for us to know at exactly what time or at what generation of bird ancestry the jump from one type to the other came. Assume that as you wish; the significant thing is this: *when the change did come it came between the adult of one race and the egg of the next.*

The first bird grew from a germ, an egg, that had the qualities of a bird—hence was a bird. One must not lose track of the fact that the egg is the animal, even though immature, that the adult may be considered as something added to the earlier stage.

Now let us make use of the definitely accepted principle in heredity and variation that, briefly stated, is: New characters arising in the course of evolution come at the time of conception, at the time when the two elements from the parents combine. Therefore, the new features that distinguish the first bird originated from parents that did not possess them, that were reptiles. It is possible that some one may argue that the descendant, the offspring, of a reptile must be a reptile also; that depends entirely upon our definitions. With that in mind we must give up the word "reptile," which no longer serves the purpose; it is a term lacking in precision for the broad group within which the transition took place from reptile to bird.

THE HYPOTHETICAL FIRST BIRD
SOFT FEATHERS THAT FIRST SERVED FOR WARMTH BECAME LONGER ON THE BACK, LEGS AND TAIL, OUT-OF-THE-WAY PLACES. STIFFENING THEY WERE LATER USED FOR FLIGHT.

To make the meaning clearer we may say that a child of human parents, today, may be so different that one is forced to give up the term "human" in an attempt to define it. The child may be a monster, removed from the normal human being by a considerable degree. In that sense the first bird was a "monster," a "sport," in the scientific use of the words; it was a new variation that went on to establish its kind for the ages to come. This is quite the usual thing in reproduction, and men set out with purpose and understanding to produce new species by noting and saving such abnormal characters as may appear in various races. Burbank had a distinguished career with plants; others have succeeded with animals of many sorts.

Extending our inquiry a step further back, it is just as important and interesting to know which came first, the reptile or its egg. Again, and in the same manner, the egg must come before the adult for here, as always, the transition between the amphibian, the ancestral form, and the reptile, the new species, came between the parent of the one race and the egg of the next. Similarly, the fishes in evolving into amphibians produced the necessary change that made a new type.

When we carry the line of descent back to the simplest primordial organism we are amazed to find that the law still holds; there the whole animal was nothing more than an egg, a single-celled form. Of course these never grew to adulthood, with legs and arms and all the other adult attributes; but that does not alter our notion; it rather confirms the thought that all animal life starts from an egg.

In any discussion of the origin of birds one comes to the consideration of the nature of the earliest birds, animals with feathers, and, since flight is so characteristic a feature of them, how they came to fly. One favored theory is that certain ancient reptiles, having a habit of running rapidly on their hind legs, learned to flap their arms, at first for balancing. It is supposed that the scales on the front limbs and tail increased in length and breadth, came to be frayed on the edges, grew lighter and eventually were feathers. These scale-feathers furnished the means of flying.

I like much better the idea that feath-

ers, even though they are merely modified scales, were developed at first for warmth, as a protection for lizard-like "reptiles" that lived in the inclement weather of Permian time. The mechanics of the process fits rather well the supposed conditions of the period: (1) a more active lizard pursuing its prey or getting away from danger, (2) rising off the cold ground, (3) running on its hind legs, (4) developing softer and fluffier scales, that (5) furnished some protection from the cold and, (6) in turn contributed to greater activity. Just when warm blood came to be a part of the equipment of the birds no one can state, but it had an immediate advantage when it did come, for it enabled the creature to continue its activities when the other "reptiles" were hibernating.

For a vast period of time such a type of bird would have carried on its existence much as the other animals of its group. But from generation to generation the feathery covering would vary; the feathers would be softer or more bristly, longer or thinner, etc. Where they were longer, by chance, there might be advantage or disadvantage; for instance, if longer feathers happened to grow on the after parts of the body, behind the limbs or on the tail, they would not greatly interfere with the animal's progress. Feathers that stuck out in any other direction would be a handicap and would be eliminated by nature.

Visualize it for yourself; a prehistoric bird, perched on a limb with its long streaming feathers extended by the wind it faced. Birds to-day perch facing the wind. Or imagine this same bird running, its feathers so constructed as to conform to a highly important stream-lining.

Now it is entirely within reason that those longer feathers, extending backward from the limbs for wings and from the body to form the tail, increased in stiffness and came to be the very instruments and means of flight. Flying, in our opinion, was not done by a cold, scaly reptile, but by a bird that was already equipped with a warm covering of feathers. It is interesting to note that, while many believe the first birds flew by use of their front limbs and tail, Dr. William Beebe conceives of a four-winged origin of flight; he has called this first bird *Tetrapteryx*. Here, too, the stiffened feathers project backward from the limbs and the tail. While it is a fact that the front limbs have superseded the others in the task of carrying the birds through the air, many birds to-day show extensive feather growth from the hind limbs as well.

Summary of the Origin of Birds

The ancestry of the bird goes away back through the reptiles, amphibians and fishes, and there it is lost in obscurity.

It is our opinion that certain reptiles developed a downy coating of modified scales for protection from cold and qualified as birds.

These fluffy feathers grew longer on the backs of the limbs and body and then, adapting themselves to a new purpose, made it possible for the birds to leap, to soar and eventually to fly.

We believe the egg came before the bird—answering an old, old question—because:

(1) No bird ever came otherwise than from an egg.

(2) An egg is a bird as truly as is the adult.

(3) New variations always arise with the egg's forming.

(4) All animal life has had its ultimate origin in a single-celled type—an egg.

Shortly after the Great Coal Period a scaly reptile laid an egg that had qualities not existing in the parent; that was the first bird.

FORTY YEARS OF MATHEMATICS

By Professor G. A. MILLER
DEPARTMENT OF MATHEMATICS, UNIVERSITY OF ILLINOIS

It is always interesting to consider definite evidences of progress in a scientific subject, especially since the vast recent growth of the scientific literature makes it more and more difficult to evaluate the nature of various supposed advances. About forty years ago a standard work of reference began to appear under the title, "Encyklopädie der mathematischen Wissenschaften," which enlisted as never before the services of leading mathematicians of various countries. The number who finally had shared in the preparation of this work exceeded two hundred, and it seems reasonable to assume that the various parts thereof represented at the time of their appearance about the best knowledge along their lines that was then available. The first article thereof relates to arithmetic and appeared in 1898. In view of the elementary character of this subject it is unusually easy to understand its shortcomings, especially with respect to its historical references, to which the present article is explicitly restricted.

Note 18 on page 12 of Volume 1 consists of eight sentences. Six of these involve assertions which are now commonly known to be incorrect. As this note relates to negative numbers and hence is within the comprehension of nearly all educated people it may be of sufficiently wide interest to consider here briefly the nature of some of these incorrect assertions which so recently were accepted by the mathematical élite. In the first sentence of this note it is asserted that in a logical development of arithmetic the introduction of the negative numbers must precede that of the fractions. The fact that this is not now commonly accepted is illustrated by the article on general arithmetic in the recent Italian "Enciclopedia delle Matematiche Elementari," where positive fractions are treated before the negative numbers. The latter are included therein among the "numeri relativi," page 167, while the former appear on page 143. In the third sentence of this note it is asserted that the first traces of negative numbers appear in the work of the Indian mathematician Bhaskara (born in 1114), who distinguished between the positive and the negative square roots. It is now well known that even the ancient Babylonians occasionally used negative numbers and that Indian mathematicians used such numbers more than five hundred years before the time of Bhaskara.

In the fourth sentence of the given note it is asserted that the Arabs recognized negative roots, while in the recent third edition of Volume 2 of J. Tropfke's "Geschichte der Elementar-Mathematik" it is explicity stated, on page 97, that it results from the text-book on algebra by Alkarhi (about 1010), and others, that the Arabs considered negative solutions as inadmissible. In the following sentence of this note the date of the "Ars Magna" of H. Cardan is given as 1550 instead of 1545, and in the next to the last sentence of this note it is asserted that Th. Harriot (1560–1621) was the first who used negative numbers by themselves and allowed them to appear separately as a member of an equation. On the contrary, O. Neugebauer recently pointed out that this credit belongs to the ancient Babylonians.[1] Finally, the last sentence of the

[1] "Mathematische Keilschrift Texte," part 3, page 38, 1937.

given note contains two misstatements in regard to the work of R. Descartes (1596–1650). The former of these asserts that the actual calculating with negative numbers begins with Descartes, while it is now well known that it is posterior to Descartes. It is also stated here that R. Descartes assigned sometimes a positive value and sometimes a negative value to the same letter, which is also now commonly known to be inexact.

The misstatements just noted naturally would be of much less general interest if they did not appear in a work which is still widely consulted by those who seek reliable information and which only forty years ago had the endorsement of some of the foremost mathematicians living at that time. Elementary mathematics is still too commonly regarded as a subject exhibiting comparatively little progress in recent times, and hence it is especially important to emphasize the fact that its history exhibits remarkable recent advances. Among the other evidences of these advances found in the given encyclopedia article we may cite that on page 5 of this article it is stated that the calculation with letters, with the employment of the symbols $=$, $>$, $<$ and the operational symbols, was first developed in the sixteenth century. It is now well known that the symbols $>$ and $<$ for greater than and less than were introduced by Harriot in the first half of the seventeenth century (1631) in his "Artis analyticae praxis," and that some of the now common operational symbols of arithmetic, including the double sign $\pm$ and $\times$ for multiplication, were also introduced after the close of the sixteenth century. On the other hand, the ancient Greeks calculated already with letters which were assumed to represent general numbers.

On page 9 of the given encyclopedia article it is stated that Diophantus, who is commonly regarded as the most noted Greek algebraist, used the final sigma of the Greek alphabet to represent the unknown quantity. While this is in accord with the view commonly expressed forty years ago, the noted English historian of Greek mathematics, T. L. Heath, has since then given various reasons for assuming that this symbol is a contraction of the first two letters in the Greek word for number, and the latter view has since then been widely accepted as the more reasonable one, even if it is not possible to speak with perfect assurance about such matters. At any rate, the positive statement that the given symbol is the final sigma of the Greek alphabet can not now be regarded as an up-to-date statement relating to the symbol used by Diophantus to represent the unknown quantity in algebra.

On page 21 it is stated that J. Kepler (1571–1630) introduced the decimal comma, while it is now known that J. Napier (1550–1617) was the first to use this now very common symbol. A much more serious misstatement on this page is that the ancient Babylonian astronomers used fifty-nine different number symbols in their representation of the positive integers to the base 60 corresponding to our nine digits in representing the positive integers to the base 10. It seems quite remarkable that such a very unreasonable statement was commonly accepted as true forty years ago, since the use of fifty-nine different numerical symbols in the early stages of civilization is in disaccord with the slow development of the early numerical notations. The use of the sexagesimal system of numerical notation on the part of the ancient Babylonians still presents various unsolved questions, and many remarkable mathematical advances were made by them, but they employed only a small number of different numerical symbols, and only two of these were com-

monly used to represent the positive integers up to 60.

The preceding remarks relating to historical errors which were current forty years ago are here of interest primarily because they may serve as a background to explain the numerous errors which appear in various current textbooks on the history of mathematics. The most influential of these was the "Vorlesungen über Geschichte der Mathematik," by M. Cantor, which began to appear in 1880 and was very favorably received, notwithstanding its numerous inaccuracies. In fact, the misstatements noted above were partly due to these inaccuracies. In 1888 W. W. R. Ball published the first edition of his "Short Account of the History of Mathematics," which involves a relatively larger number of inaccuracies but became very popular, and its later editions were translated into various other languages. In America the text-books by F. Cajori which were largely based on those just noted began to appear in 1893 and helped to transplant a large number of erroneous views in attractively written books. The later text-books by D. E. Smith did little towards correcting the inaccuracies which had been embodied in the most commonly used text-books on the history of mathematics.

The most effective work towards removing inaccuracies from the text-books on the history of elementary mathematics during the last forty years has been J. Tropfke's "Geschichte der Elementar-Mathematik," which began to appear in 1902. The first edition was published in two volumes, while the second edition appeared in seven small volumes from 1920 to 1924. In 1930 a third enlarged edition in seven volumes began to appear, but its publication has proceeded slowly. The third volume of this edition was published in 1937. By means of these revisions it was possible to take advantage of recent discoveries and to correct various mistakes in the earlier editions. In particular, the third volume of the third edition embodies many of the recent discoveries relating to the solution of the quadratic equation and devotes about 68 pages to this subject, while only 27 pages were devoted thereto in the preceding edition, which appeared only about 15 years earlier. There are few other subjects of elementary mathematics whose history has been more fundamentally extended during the last forty years than that of the quadratic equation, whose development can now be traced through about four thousand years.

The most original work on the history of mathematics which was published during the last forty years is the "Vorlesungen über Geschichte der Antiken Mathematischen Wissenschaften," by O. Neugebauer (1934), which is largely devoted to the mathematics of the ancient Babylonians and the ancient Egyptians, and may be regarded as the first effort to give a systematic exposition of pre-Grecian mathematics. In the preface to this volume it is stated that ancient mathematics consists primarily of two developments which are widely separated with respect to time. The more extensive of these two developments is due to Greeks and is exhibited among others in the works of Euclid, Archimedes and Apollonius, while the other is in the main more than a thousand years older and is largely due to the ancient Egyptians and the ancient Babylonians. Comparatively little is as yet known in regard to the influence of the latter on the former, since the ancient Greeks seldom gave references to the earlier work. In particular, the fundamental "Elements" of Euclid contain no historical references, but this may be more largely due to the difficulty of getting accurate historical information at that time than to a lack of generosity on the part of the ancient Greeks. Even at the present

time carefully selected historical references are seldom given.

The given volume by O. Neugebauer emphasizes the fact that the ancient Babylonian and Sumerian mathematics was largely algebraic. It included the partial solution of algebraic equations of different degrees, but those of the second degree are especially interesting, since some of the methods used here are general, but their significance was not fully understood until about four thousand years later when the number concept had been extended so as to include a clear theory of the negative and the complex numbers. One of the profoundest facts of ancient mathematics is that in the algebraic work it is always hampered by a lack of insight into the number concept, and it is important to note that this insight was not secured until about the beginning of the nineteenth century. Hence all the earlier algebraic work was bound to suffer as regards generality and elegance, especially with respect to the solution of algebraic equations. The partial solutions of such equations which we meet in the work of the ancients and in that of the middle ages naturally arouse our pity more than our admiration, even if elegant special devices are frequently met in the older developments.

The American student of the history of mathematics is naturally especially interested in the question of the reliability of the various sources of supposed information. While the rapid recent progress in this history is encouraging it also implies that greater care must be exercised by those who desire to avoid the spreading of mathematical myths which are still too common in our literature. Many of these have been so modified by various popular writers as to appeal strongly to the imagination of young students, and hence they have been eagerly adopted by writers of text-books. It is, however, reasonable to assume that they can not be as stimulating permanently as the truths which are reinforced continually by the addition to our knowledge and tend to explain new facts as they come within our enlarged vision. The interrelations between mathematical results naturally stand out clearer as our knowledge increases and tend to exhibit inconsistencies with popular errors. It might appear almost impossible that so many errors could appear in some of our popular histories of mathematics if one did not consider that only forty years ago such a standard work of reference as the "Encyklopädie der mathematischen Wissenschaften" embodied much which is now known to be untrue.

The deep interest in the history of mathematics on the part of the promoters of this large encyclopedia is attested by the fact that it was planned to include this subject in the final volume thereof, which plan unfortunately was later abandoned. Since many historical facts are unusually rich in their implications they may become fertile ferments in the minds of the thoughtful students, and hence teachers colleges have commonly included courses in the history of mathematics for those who prepare themselves to teach mathematics in the schools of our country. Much of the recent progress in this subject is not yet available in the English language nor in any other one language, but at the present time more of it appears in German than in any other one language. According to J. W. L. Glaisher, "no subject loses more than mathematics by any attempt to dissociate it from its history."[2]

[2] *Nature*, 42: 466, 1890.

BOOKS ON SCIENCE FOR LAYMEN

FORTY YEARS OF SCIENCE[1]

SEVERAL general surveys of science have appeared since the World War. This latest one consists of ten lectures delivered at Cambridge, England, in 1936, the plans for which were developed by the History of Science Committee, of which Dr. Joseph Needham was chairman, and Mr. Walter Pagel was secretary.

The general subject of the lectures was the progress of science in the forty years from 1895 to 1935. Among the speakers were such world-famous scientists as Lord Rutherford, Professor W. L. Bragg, Dr. F. W. Aston and Sir Arthur Eddington. All except Sir William Dampier were actively connected with Cambridge when the lectures were delivered; the addresses by Lord Rutherford and Professor G. H. F. Nuttall were their last ones before their deaths. These lectures were followed in 1937 by a larger series on the earlier history of science. Concerning the reception of these lectures the editors state: "It was for us a moving experience to see the great concourse of students, many having to stand or sit on the floor, which gathered to hear these expositions of progress in the sciences during the past forty years by those who had themselves taken some of the foremost parts in it."

It is evident from the origin of these lectures that they were planned for oral presentation. Indeed, Lord Rutherford's addresses were reported stenographically and put in form for publication after his death. As addresses by distinguished and revered scientists before their students, these discussions of the history of science were a great success. Lord Rutherford and Professor Bragg, for example, could with all propriety and telling effect speak freely and intimately of their own work, but the printed page lacks the warm glow of the person himself. Consequently in general the reaction of a reader of the lectures will fall far short of the response of the students who listened to them.

From the standpoint of the reader the volume lacks close unity, though it is somewhat more than a series of unrelated essays. It is very difficult for a number of authors to adhere closely to a fixed plan and to maintain general similarity of style in preparing a book. To do so would result in a more complete and coherent discussion of some field, but it would be at some cost of freedom and spontaneity of expression. The reader of this volume will feel its lack of completeness and a consistently followed plan. In spite of the fact that the period from 1895 to 1935 was the one under discussion, two lectures by Professor Francis M. Cornford and Sir William C. Dampier begin with the Greeks. Lord Rutherford's two lectures on "Forty Years of Physics" frankly touch only the history of radioactivity and atomic structure, to which he made very important contributions. On the other hand, Professor Bragg's "Forty Years of Crystal Physics" and Professor Aston's "Forty Years of Atomic Theory" are strictly on their subjects and comprehensive, though requiring for their clear understanding a considerably greater background of information in the respective fields than most readers will have. In "Forty Years of Astronomy," Sir Arthur Eddington discusses excellently a number of the principal astronomical advances in the period. Professor John A. Ryle, in "Forty Years of Physiology and Pathology," spent so large a fraction of his space to

[1] "Background to Modern Science." A series of lectures at Cambridge, England, by ten eminent British scientists. xii + 243 pp. $2.00. The Macmillan Company.

earlier periods, especially in well-merited tributes to the remarkable work in gastric physiology of William Beaumont (1785–1853) and to the early work of Ivan Pavlov (1849–1936), as well as to Hunter, de Réaumur, Prout and others, that the modern period, except as to work on the stomach, is very sketchily referred to. Professor G. H. F. Nuttall, in "Forty Years of Parasitology and Tropical Medicine," limits himself to discussions of malaria and yellow fever. The last two chapters on "Forty Years of Evolution Theory" and "Forty Years of Genetics," by Professor R. C. Punnett and Professor J. B. S. Haldane, respectively, have so much subject-matter in common that the fields they were probably intended to cover are not clearly distinguishable. The former, however, is devoted largely to earlier periods, beginning with the Greeks and enlarging on the work of Darwin and his contemporaries; the latter considers much more the work beginning with that of Bateson published in 1895 and that growing out of the discovery of the earlier work of de Vilmorin and Mendel. Among the interesting results of breeding experiments cited are those that resulted in the development of new strains of wheat which have been of great economic importance. As interesting as these two chapters are, one finishes them with the feeling that the authors have only touched lightly here and there on important subjects that would be much more interesting if they were more systematically and thoroughly expounded.

F. R. M.

LIFE AND LIVING FROM AN EVOLUTIONARY STANDPOINT[2]

WITH a healthy skepticism for scientific creed, Dr. Bradley probes into the problem of life and living from an evolutionary standpoint. He is concerned with the racial history of animals and particularly of man. With a fine sense of reality, and a happy turn of quiet humor, Dr. Bradley examines the various patterns of animal existence which have permitted them to survive, or that have at times firmly ordered their extinction. Then, with the anatomy of life exposed from the standpoint of its "musts and must nots" according to the dictates of stern Mother Nature, the author appropriately devotes his closing chapters to man.

The book presents a pleasing, broad, comprehensive, understanding outlook across the various fields of natural science. It passes over the present-day emphasis upon minute details, to bring clearly into focus not the leaves of the trees, but the forest and the geographical topography beneath the forest. The volume is most refreshing for those of us who spend our thinking time dealing with anatomical or physiological detail, and who accept the present without considering seriously the implications of the past.

Dr. Bradley reviews the broad theories of the origin of life with a sense of distrust for such pure speculation. Measuring man's attempt to solve the riddle of the phenomenon of life itself leads him to point out that one frontier conquered brings us only to another blank wall. Even when the mechanism of protoplasm has been dissected molecule for molecule, there is every reason to doubt that the human mind will understand it as a unit or will be able to reassemble it. The probability is strong that the whole has greater and different properties than the sum of its parts.

In evolution, attention is focused not so much upon the importance of change, but upon stability, particularly from the angle of biologic success. Granted that success must always be a matter of opinion, it is likely true that animals which

[2] "Patterns of Survival." By J. H. Bradley. 223 pp. $2.25. The Macmillan Company.

have been in continuous existence for long periods of time are probably more successful than those that became over-specialized and were exterminated. The problem of biologic success is analyzed critically with a view to determine what modes of life, food habits, environment and reproductive factors have been successful for animals in the struggle for existence.

Against a nicely developed background, man is brought into the spotlight. Dr. Bradley holds no halo over his head from the standpoint of present-day anatomy or future anatomical promise. But he does have faith in man's brain and his perpetual discontent. The hope is expressed that man may some day be as successful in controlling his own inner social world as he has been in controlling the outside physical and biologic world.

The book will likely find its way to the reading library of most of us, and surely our students should read it before they become lost in the complexity of detail characteristic of our present-day science.

IRA B. HANSEN
THE GEORGE WASHINGTON UNIVERSITY

BEGINNINGS OF A BILLION DOLLAR INDUSTRY[3]

DR. GIDDENS' book is primarily concerned with developments in northwestern Pennsylvania during the decade which began with the completion of the oil well drilled by E. L. Drake in 1859. The author gives proper emphasis to the fact that although Drake's well was the first one drilled for the purpose of producing oil, oil had been known to be present in springs and salt brine wells in the region for many years. The success of Drake's operation and the high price obtained for oil at that time provided the basis for an astoundingly swift development, which is well portrayed by the author.

The choice of a decade as the time of "birth" of the oil industry is amply justified by the development of production, transportation, refining, marketing and financing activities during this period. Dr. Giddens treats all these phases of the new industry, calling attention to the numerous problems which had to be solved to establish the economic status of the newly developed mineral resource. During this period pipe lines were established for transportation, refining methods to obtain a satisfactory illuminating oil were developed, lamps capable of burning the oil efficiently were invented, and markets were developed in the United States and the principal countries of Europe. The only apparent omission in rounding out the picture is mention of the first application of principles of geology to prospecting for petroleum. A good foundation for the modern application of geology to petroleum exploration was published in a scientific paper by T. Sterry Hunt, of the Geological Survey of Canada, in 1861. During the ensuing eight or nine years several other geologists published statements calling attention to the relationship between geologic conditions and oil accumulation. Structure contour maps were included in a geological report on oil properties published in 1870, so there can be little doubt that they were in actual use contemporaneously with the developments described in Dr. Giddens' book.

"The Birth of the Oil Industry" is not only of considerable general interest but should be of especial interest to those engaged either in the modern petroleum industry, in the development of Pennsylvania or in the operation of economic forces under the American system. Dr. Giddens' book vividly portrays the initiative and resourcefulness of American entrepreneurs of that period. The numerous references included make original data readily available to those interested in further investigation of the subject,

[3] The Birth of the Oil Industry. By Paul G. Giddens. 216 pp., 37 plates and maps. $3.00. The Macmillan Company.

while the "Introduction" by Ida M. Tarbell provides an excellent summary of the book for the use of the less interested reader. "The Birth of the Oil Industry" is to be highly recommended.

GAIL F. MOULTON

IS IT PROBABLE?[1]

THE title "Your Chance to Win" and such chapter headings as "Heads or Tails," "Poker Chances" and "Lotteries, Craps, Bridge" might lead one to conclude that this book is a manual for gamblers. But such other chapter headings as "Fallacies," "The Grammar of Chance," "From Chance to Statistics," "Fallacies and Statistics," "Statistics and Science" and "Business and Statistics" indicate that it probably has a serious side.

As a matter of fact, Dr. Levinson has written a thoroughly scientific work. Instead of proceeding with orthodox academic ponderosity from definitions that have no relation to ordinary experience, he starts with things with which all the world is familiar—with such things as luck and gambling and superstition and fallacies, not in the abstract but in concrete illustrations from things in every-day life. On the one hand, he exposes the erroneous ideas of those who gamble and the improbability of their winning; on the other hand, he makes clear in what sense chance and probability, as they are called, play rôles in the events in which we are interested. In a very entertaining and illuminating chapter on "Gamblers and Scientists" he explains how, in the seventeenth century, what had been thought of as lawless chance was organized into the theory of probability, which has only recently been generally recognized as one of the best tools of theoretical science. In "The Grammar of Chance" he defines very exactly and illustrates clearly the fundamental terms that are used in the theory of probability.

Two or three chapters are devoted to several common games of chance, including tossing of coins, poker and roulette. As entertaining as they are, with sparkling illustrations of human weaknesses and errors in thinking, their real purpose is to give the reader a clear understanding of a subject beset with many pitfalls and to prepare him for straight thinking about the nature and power of statistics in relation to such important and varied subjects as science, advertising and business.

There is probably no other book on the subject of probability and statistics that is so entertaining or that throws incidentally so much light on a certain class of human weaknesses centering in the wide-spread and possibly increasing desire to get something for nothing. At the same time there is probably no other book that makes clearer the real nature of probability and the errors that may be committed in applying the theory of probability. All this is accomplished without the use of complicated mathematical expressions. The discussions of applications of statistics to science, illustrated by Dr. Rhine's experiments on telepathy and clairvoyance, and to advertising and business, relate largely to principles rather than to the mechanics of obtaining numerical results. Yet a reader who has understandingly followed the discussions would be able to apply them safely, much more safely than one could apply formulas whose basic principles he did not fully comprehend.

F. R. M.

[1] "Your Chance to Win." By Horace C. Levinson. 343 pages. Farrar and Rinehart, Inc.

PROFESSOR WALTER B. CANNON

THE PROGRESS OF SCIENCE

PROFESSOR WALTER B. CANNON, PRESIDENT OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

For its new president the association has selected a man in whom an intense devotion to scientific work, tireless energy and a rare gift for framing fertile experimental inquiries have combined to make him one of the world's leaders in physiology and a force in scientific medicine. During the Richmond meeting, where he was elected to the presidency, Dr. Cannon was in New York taking part in another gathering of scientific men. There in conversation with several old students he spoke enthusiastically of experimental results recently obtained and revealed the greatest eagerness to get back as soon as possible to his laboratory in order to push forward the new work. One may confidently predict that during his presidency Dr. Cannon will be in the vanguard of those who are contributing directly to the advancement of science.

Physiologists have two good reasons for interest in the town of Prairie du Chien, Wisconsin. It was there that Dr. William Beaumont, the pioneer of experimental physiology in this country, carried out, during the years 1829–31, some of the most significant of his studies on the "fistulous" Alexis St. Martin, studies which constituted the most important work on the physiology of gastric digestion before the time of Pavlov. And it was there that Walter Bradford Cannon was born on October 19, 1871. Twenty-five years later, while a first-year medical student he began a series of experiments which placed him beside Beaumont and Pavlov as one of the great contributors to our knowledge of the physiology of digestion.

In 1896 he graduated from Harvard College and entered the Harvard Medical School. Very soon he was asking the professor of physiology, Dr. Henry P. Bowditch, for an opportunity to undertake a physiological investigation. Bowditch suggested that the newly discovered Roentgen rays might be used to study the phenomenon of swallowing, and on December 4, 1896, the first experiment was performed when Cannon and a fellow student watched pearl buttons pass down the esophagus of a dog. Almost at once it was found that by mixing bismuth subnitrate with the food both the movements of the gastric contents and the concentrations of the stomach wall could be clearly seen with the x-rays. There followed, over a period of fifteen years, observations and experiments on nearly every aspect and condition of gastro-intestinal motility; in 1911 Dr. Cannon summarized this work in a monograph on "The Mechanical Factors of Digestion."

On his graduation in medicine at Harvard in 1900 Dr. Cannon became an instructor in the department of physiology. Two years later he advanced to an assistant professorship, and in 1906 he succeeded Dr. Bowditch as George Higginson professor of physiology. The studies on the digestive tract terminated in 1912 with the demonstration that the pangs of hunger are due to prolonged rhythmic contractions of the stomach wall. It was at this time that Dr. Cannon conspicuously exhibited a trait which Michael Foster, writing of Claude Bernard, put down as "perhaps the chiefest sign of genius in inquiry." As Foster expressed it, "his instinct guided him to leave the road at the right turning, and to follow a bye-path which brought him a great result." The sign which he heeded was the cessation of gastro-intestinal movements that appeared whenever one of his experimental animals grew restive or displayed anger. Analysis of this phenomenon led to experiments which brought out the important fact that under conditions of physiological stress, such as emotional excitement, asphyxia, exposure to cold

and hypoglycemia, the sympathetic nervous system and its constituent part, the adrenal medulla, act to effect visceral adjustments which are nicely adapted to the preservation of the individual. In 1915 these investigations were reported in the first edition of "Bodily Changes in Pain, Hunger, Fear and Rage." The second edition (1929) contains, in addition to much new evidence bearing on the general theme, an account of some notable experiments on thirst and a fresh theoretical treatment of the origins of emotional behavior and emotional experience.

The relation of the autonomic nervous system to the self-regulation of physiological processes was a major concern of Dr. Cannon for a period of twenty years. Gradually it became clear to him that this system plays an important part in the maintenance of a relatively constant internal environment. The importance of steady states in the organism has been emphasized by a number of physiologists, but nowhere has this concept been presented with such clarity as in "The Wisdom of the Body," which came from Dr. Cannon's pen in 1932.

The present phase of his scientific activity grew out of his final proof of the emergency function of the sympathetic—the brilliant demonstration that after complete removal of this system animals live normally under quiet conditions, but exhibit serious deficiencies when subjected to conditions of stress. Careful examination of a mysterious acceleration of the denervated heart, which appeared with emotional excitement when the sympathectomy was incomplete, led him into the realm of the chemical mediation of nerve impulses, where he was a pioneer. It is not too much to expect that his continuation in this field will greatly elucidate the vexed question of the nature of excitation and inhibition in the central nervous system.

During the Great War the orderly sequence of Dr. Cannon's researches was interrupted by his service as a medical officer. After reaching France he soon engaged in a study of traumatic shock. His observations at the front led to investigations in London and elsewhere which will be of permanent value in explaining the circulatory depression which follows severe trauma. Later, while in charge of the laboratory for surgical research at Dijon, he did much to further the prevention of shock among the wounded.

The honors which have been awarded Dr. Cannon are so numerous that they can not be listed in the allotted space. But it would be a serious omission not to emphasize his personal characteristics. At the celebration of the twenty-fifth anniversary of his professorship Dean Edsall spoke of his possession in abundance of those qualities of personality which produce what we call character; Walter Alvarez, in reviewing the reasons which have made Dr. Cannon such a good foster-father of research, mentioned his open-mindedness to the ideas of others, his genuine interest in the problems of his students and his scrupulous fairness in apportioning credit; and finally President Lowell spoke of a quality which impresses all who know him—his very great modesty.

PHILIP BARD

THE FIFTH WASHINGTON CONFERENCE ON THEORETICAL PHYSICS

THE fifth annual Washington Conference on Theoretical Physics, jointly sponsored by the George Washington University and the Carnegie Institution of Washington acting through its Department of Terrestrial Magnetism, was held in Washington from January 26 to 28. These conferences afford opportunity for a small number of theoretical physicists investigating related subjects to discuss *informally* fundamental problems and difficulties encountered. Devoted solely to the clarification of the current status of the subject and to discovering the profitable directions for immediate attack, they are uniquely effective in ad-

ATOMIC-PHYSICS OBSERVATORY AND EXPERIMENTAL BUILDING

vancing the progress of researches considered. Vigorous discussion, such as is not possible in a called formal meeting of a scientific society or body, is encouraged and clarifies ideas, clears difficulties and indicates flaws in an argument which frequently an individual fails to see because of lack of constructive and critical contacts. The rapid development in physics during recent years emphasizes the desirability—really necessity—of personal contacts between investigators, who may be widely separated geographically, to facilitate coordination of experimental and theoretical developments. These conferences have proved of real and immediate value in furthering such contacts and understanding and the significance of current experimental and theoretical research.

Among the investigators attending the fifth conference were Professors Niels Bohr, Harold C. Urey and Enrico Fermi, all three recipients of the Nobel Prize. In addition to a number of Washington physicists, there were present Professors F. London, G. E. Uhlenbeck, J. H. Van Vleck, H. A. Bethe, G. Breit, E. U. Condon, I. I. Rabi, A. E. Ruark, F. Bitter, H. Grayson-Smith, F. Seitz, O. Stern, L. Rosenfeld and others. In all, between 50 and 60 men representing 22 universities and research organizations were present at the four sessions during January 26 to 28.

Each conference is planned about some major theme. As in earlier conferences, the aim of the discussions was to clarify the present status of a few important theoretical difficulties and problems in order that investigators actually attacking them might indicate to each other and examine together directions of possible progress. The subject of the fifth conference was the theory of low-temperature physics. The subjects discussed include the properties of liquid helium and of liquid hydrogen and deuterium, the interpretation of data on the adiabatic demagnetization of paramagnetic salts at

PHYSICISTS ATTENDING THE WASHINGTON CONFERENCE

Reading from left to right, starting at bottom row: Stern, Carnegie Tech.; Fermi, Rome, Columbia; Fleming, Carnegie Institution; Bohr, Copenhagen, Princeton; London, Duke, Paris; Urey, Columbia; Brickwedde, Bureau of Standards; Breit, Wisconsin, Carnegie Institution; Silsbee, Bureau of Standards; Rabi, Columbia; Uhlenbeck, Columbia; Gamow, George Washington; Teller, George Washington; Mrs. Mayer, Johns Hopkins; Bitter, Mass. Inst. of Tech.; Bethe, Cornell; Grayson-Smith, Toronto; Van Vleck, Harvard; Jacobs, Mass. Inst. of Tech.; Starr, Mass. Inst. of Tech.; Hebb, Duke; Squire, Pennsylvania; Kuper, U. S. Public Health Service; Mahan, Georgetown; Myers, Maryland; Roberts, Carnegie Institution; Critchfield, George Washington; Baroff, U. S. Patent Office; Bohr, Jr., Copenhagen; Meyer, Carnegie Institution; Herzfeld, Catholic University; Lord, Johns Hopkins; Inglis, Johns Hopkins; Wulf, U. S. Department of Agriculture; Wang, Peking, Carnegie Institution; Johnson, Carnegie Institution; Mohler, Bureau of Standards; Scott, Bureau of Standards; Vestine, Carnegie Institution; Rosenfeld, Liège, Copenhagen, Princeton; Seitz, Pennsylvania; Diecke, Johns Hopkins; Mayer, Johns Hopkins; Hibben, Carnegie Institution; Tuve, Carnegie Institution; O'Bryan, Georgetown; Hafstad, Carnegie Institution; Cohen, Columbia; Hoge, Bureau of Standards; Sklar, Catholic University; Rossini, Bureau of Standards.

temperatures below 1° absolute, and the phenomenon of superconductivity. Differences in the physical properties of the isotopic modifications of hydrogen at low temperatures were also discussed.

Professor F. London, of the Institut Henri Poincaré of the University of Paris, who has been visiting professor at Duke University for some months, presented his recently developed theoretical considerations concerning many striking phenomena observed in liquid helium below the transition-point at 2°.2 absolute. He also discussed the theory of superconductivity.

Professor Van Vleck, of Harvard University, and others referred to recent considerations bearing on method of Giauque and Debye in obtaining temperatures below 1° absolute by the adiabatic demagnetization of a paramagnetic salt and on the property of matter at these temperatures. In considering the experiments of Simon, Kurti and coworkers on iron ammonium alum at temperatures below 1° absolute, Drs. Hebb and Squire pointed out that magnetic properties provide the only thermometer available for such measurements. Yet temperatures as low as 0°.006 absolute are attainable only because magnetic anomalies exist at these very low temperatures. The reduction of the magnetic temperatures to the absolute scale was critically reviewed.

An unexpected event at the conference was the first information in this country given by Professors Bohr and Fermi regarding the chemical discovery of Professor Hahn and his coworkers of disintegration of uranium into the comparatively light element barium (and other residues), with the attendant release of approximately two hundred million electron-volts of energy per disintegration. The physical interpretation of this was first made by Frisch and Meitner. As indicated elsewhere in this issue of THE SCIENTIFIC MONTHLY, direct experimental observation of such disintegration was independently accomplished at Copenhagen on January 15, at Columbia on January 25, and at Johns Hopkins and the Carnegie Institution of Washington on January 28.

A more detailed account of the scientific discussions will be published in *Science*. The results, as in the past four years, indicate conclusively the value of such "working conferences" in which a small group of men actively engaged in theoretical research may be invited to take part. They are particularly appropriate and effective in developing interest in the fundamental aspects of the theoretical and experimental researches in nuclear physics and magnetism being developed at the George Washington University and at the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. It is hoped that the example set by the sponsors may be followed more generally by institutions lo-

GEORGE WASHINGTON UNIVERSITY BUILDINGS

SHOWING, LEFT TO RIGHT, COLUMBIAN HOUSE, THE BIOLOGICAL SCIENCE BUILDING, THE LISNER LIBRARY (RECENTLY TORN DOWN TO MAKE WAY FOR A NEW LIBRARY NOW UNDER CONSTRUCTION) AND THE SOCIAL SCIENCE HALL.

cated at other scientific centers. The success attending the Washington conferences makes it increasingly clear that fields of such possibilities so thoroughly investigated in detail require limitation each year to a few specific topics. Thus the need for limiting the number of invited conferees is generally recognized.

JOHN A. FLEMING,
Director
DEPARTMENT OF TERRESTRIAL MAGNETISM,
CARNEGIE INSTITUTION OF WASHINGTON

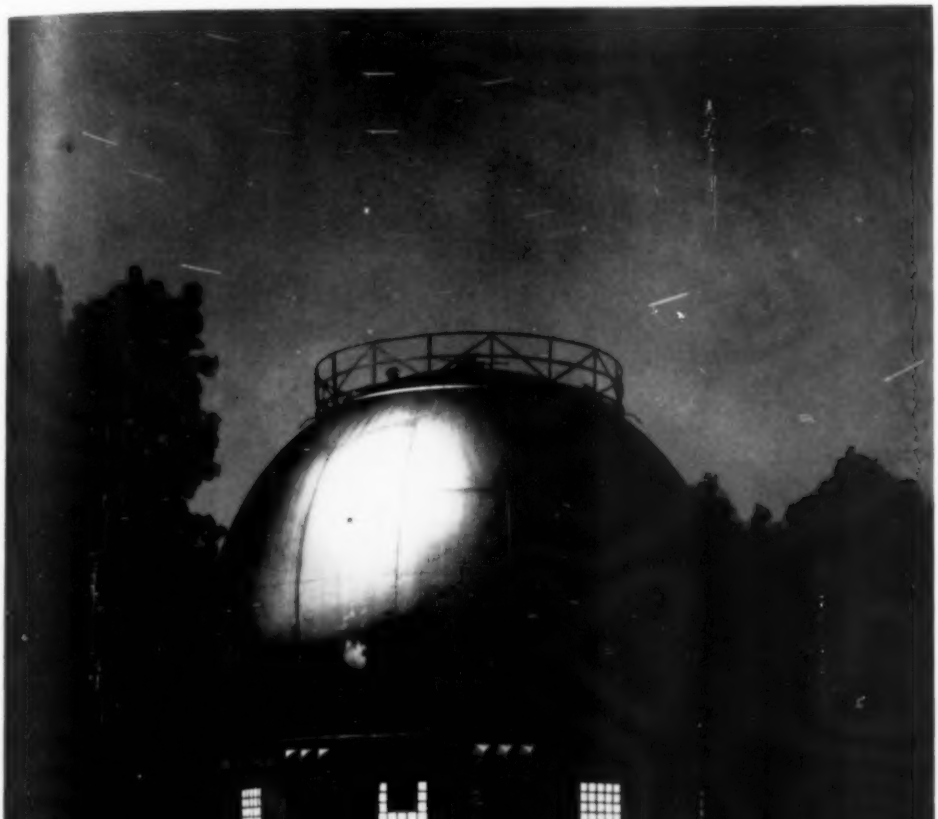
SPLITTING OF URANIUM ATOMS

ALMOST simultaneously near the end of January four experimental laboratories equipped with very high voltage electrical machines announced that they had verified the breaking up of uranium atoms into two roughly equal parts. The disintegration of the uranium atoms was produced by bombarding them with neutrons, one of the fundamental constituents of which all atoms are composed. Sensational press statements concerning the experiments played up the fact that when an atom of uranium is caused to divide into two parts by a bombarding neutron, it gives up enormously more energy than is carried into it by the neutron. This fact does not suggest the way to a new almost limitless source of energy, because in obtaining the neutrons for the bombardment much more energy is used than the uranium releases. In the domain of physics there is as yet no promise of being able to get something out of nothing.

In order to make clear the importance of these experiments it may be desirable to recall a few of the properties of atoms and of uranium in particular. A common description of atoms is that they are somewhat similar to miniatures of the solar system, consisting of central nuclei containing most of their mass and negative electrons revolving around the nuclei as the planets revolve about the sun. It is misleading, however, to carry the analogy far, for in very important respects atoms are quite unlike the solar family. The experiments under consideration pertain to the nuclei, though the chemical properties of atoms depend almost entirely upon their outer negative electrons. It is the atomic nuclei that contain the keys to the most important properties of matter, including explanations of the principal sources of the energy radiated by the stars. For this reason the recent experiments are of great interest.

Historically the sequence of experiments began in October or November when Professor Hahn and Dr. Strassmann, in Berlin, found radioactive barium in uranium which had been bombarded by neutrons. Uranium, with an atomic weight of 238, is a radioactive element which spontaneously degenerates into lead through a series of about a dozen steps in which small particles are successively emitted. The degeneration stops at the one of isotopes of lead which has an atomic weight of 206. Since the atomic weight of radioactive barium is about 139, it could not come from uranium by the previously known type of degeneration. For this reason Hahn and Strassmann at first suspected that the barium which they found in uranium which had been bombarded with neutrons was an impurity in the original materials.

The experimental results obtained in Berlin were communicated to Professor R. Frisch, at Copenhagen, and Dr. Lise Meitner, an exile from Germany. They suggested that the barium which had been found might have been produced by division of the uranium nuclei into two roughly equal parts. Moreover, they outlined an experimental test of the hypothesis which was based on the fact that in the suggested splitting up of uranium there would be a known decrease in total mass through what is known as the "packing effect" with a corresponding release of energy, in conformity with the principle that the sum of mass and energy, in suitable units, is constant whatever transformations they may undergo.



THE ATOMIC-PHYSICS OBSERVATORY

TAKEN BY THE LIGHT OF THE FULL MOON. THE CURVED STAR TRAILS SHOW THAT THE CAMERA WAS POINTED NORTH, AND THAT THE EXPOSURE WAS A LONG ONE.

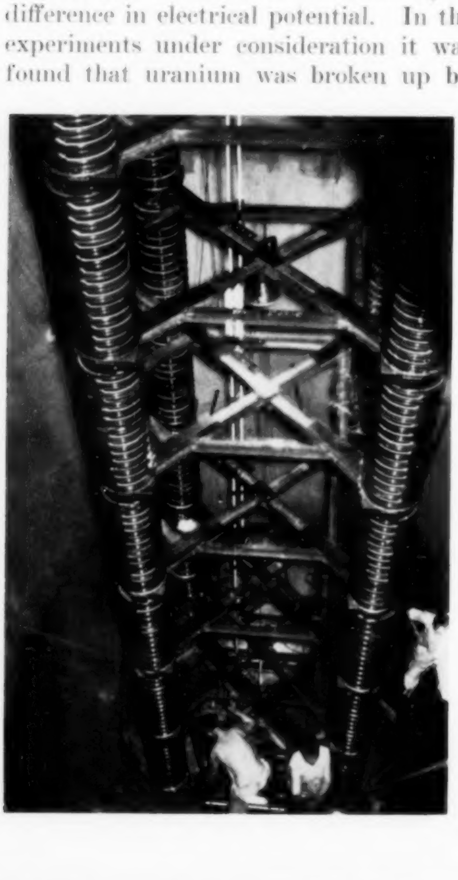
AN INTERIOR VIEW OF THE ATOMIC-PHYSICS OBSERVATORY

Since a minute quantity of matter is equivalent to a great amount of energy, the calculated energy released in this process would be very large.

Frisch, in Copenhagen, found the predicted energy effects in about the middle of January, but they were not made public. They were found wholly independently by Drs. Dunning and Pegram at Columbia University on January 25, and also independently and simultaneously, on January 28, by Drs. Fowler and Dodson at Johns Hopkins University and by the physicists of the Terrestrial Magnetism Laboratory of the Carnegie Institution of Washington.

In the fields of cosmic rays and nuclear physics scientists express energy in terms of electron-volts, a term derived from the acceleration of negative electrons by a difference in electrical potential. In the experiments under consideration it was found that uranium was broken up by neutrons having surprisingly low velocities, of the order of one mile per second. Thus when an atom of uranium was bombarded with a neutron having an energy of 1/30th of an electron-volt it broke up with the formation of barium, and the energy released in the process amounted to about 250,000,000 electron-volts per atom. But the most efficient known means of obtaining a slow neutron to break down a molecule of uranium requires the expenditure of about 3,000,000,000 electron-volts of energy. Therefore, disregarding the scarcity of uranium, the process has as yet a maximum energy efficiency of less than 10 per cent.

THE 19-FOOT HIGH-VOLTAGE BALL BEING LOWERED ONTO THE 26TH PORCELAIN SUPPORT-COLUMNS INSIDE THE 5,000,000-VOLT ATOMIC-PHYSICS OBSERVATORY OF THE CARNEGIE INSTITUTION DEPARTMENT OF TERRESTRIAL MAGNETISM IN WASHINGTON.



The chief importance of this discovery is no doubt the added information that it gives regarding the structure of the atomic nucleus. The fact that such a relatively large amount of energy is evolved in each individual atomic disintegration is of striking interest.

M. A. TUVE

THE ASSOCIATION—PAST, PRESENT AND FUTURE

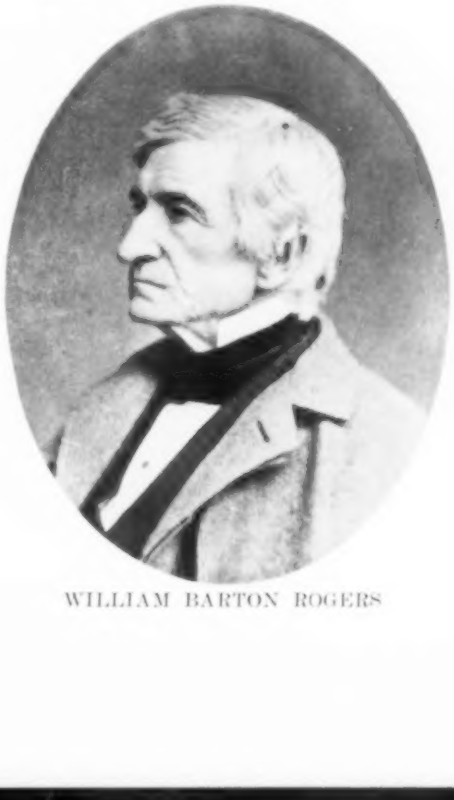
In a recent number of the Monthly two different men were said to have been the first president of the American Association for the Advancement of Science, one writer assigning the presidency to the chairman of the organizing committee. Since my memory doesn't reach back to the first meeting, which was held in Philadelphia on September 20, in 1848, I have looked up the early history of the association and also a few statistics relating to its membership from its origin down to the present time.

For several years previous to 1848 there had been considerable discussion in this country about organizing a truly national scientific society. At that time science consisted of two general divisions, natural philosophy and natural history, the former including the physical sciences and the latter the biological. The material resources of the country naturally aroused great interest in the physical sciences, especially geology, and the relatively unknown fauna and flora stimulated an equal interest in the biological sciences. The obvious advantages of a general society including all the sciences had been exemplified by the British Association for the Advancement of Science, which was organized about sixteen years earlier.

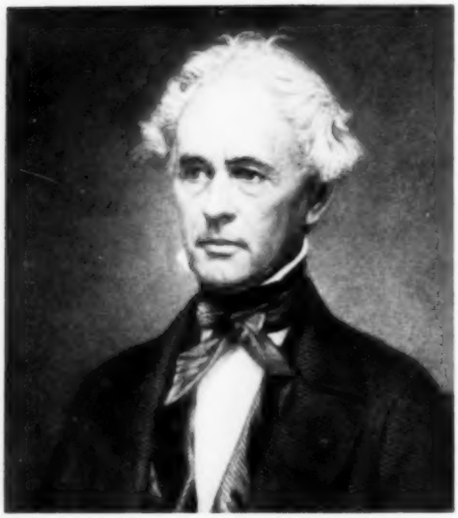
At a meeting of the Association of American Geologists and Naturalists, held on September 24, 1847, the first officers of the newly formed American Association for the Advancement of Science were elected. William C. Redfield was chosen president of the association for 1848, Professor Walter R. Johnson, secretary, and Professor J. Wyman, treasurer. Professor William B. Rogers, of Virginia, was chairman of this meeting, as well as of the first meeting of the association held in Philadelphia the following year. Thus the first officers of the association were elected in September, 1847, and its first meeting was held in September, 1848. The association has held at least one meeting each of the 91 years since its organization, except in 1861 to 1865, inclusive. The Virginia meeting held in Richmond in December was the one hundred third regular meeting of the association, in addition to the meetings of the Pacific Division and of the Southwestern Division.

For many years the number of members of the association was not so great that it was necessary to hold its meetings only in cities having accommodations for large conventions. Its total membership during the first thirty years of its existence did not exceed a thousand, and usually only a few hundred persons attended its meetings. During these years it could meet in such cities as Newport, R. I., Troy, N. Y., and Dubuque, Iowa. Now its winter meetings can be held only in cities having accommodations for at least 5,000 scientists.

One of the great advantages of meet-



WILLIAM BARTON ROGERS



WILLIAM C. REDFIELD

ings of scientists from various fields is the opportunities they offer for extending acquaintanceships, especially among those in different fields, because specializations have gone so far that cooperative work and integrations of science are becoming daily more and more important. In order to increase these advantages the meetings should be a little more leisurely, with the rigors of scientific sessions interspersed more freely with social gatherings and excursions. Perhaps the custom of the British Association of beginning its meetings near the middle of one week and continuing them over into the following week, with Saturday and Sunday free from formal sessions, is one that might be advantageous to the American Association. A longer meeting presents, of course, an economic problem that is often important for younger scientists. At Richmond a large number of them were provided excellent accommodations in what are known as Tourist Homes, which were not at all makeshift places for staying over night but high-grade residences in which paying guests are received. The possibilities in this direction have not begun to be explored. But this is somewhat aside from the subject under discussion except as it bears on the future growth of the association and the increases in the size of its meetings.

A bird's-eye view of the progress of science in America and of the growth of the association can be obtained from its membership by decades. Since its fiscal year ends on September 30, the following statistics are for that date except in the case of the last one, February 4, 1939.

Year	Members	Meeting Place
1848	461	Philadelphia
1858	962	Baltimore
1868	686	Chicago
1878	962	St. Louis
1888	1,964	Cleveland
1898	1,729	Boston
1908	6,072	Chicago
1918	?	Baltimore
(1920	11,442	St. Louis)
1928	16,328	New York
1938	19,347	Richmond
1939 (Feb. 4)	20,048	

What of the future of the association? Of course no one can answer, though prophetic curves similar to those which statisticians employ could be developed. The need for the fundamental creed of science that only truth is a worthy and an acceptable goal, whatever it may be, is acute in the world. The world needs equally the sincerity of science, its single-mindedness, its adventurous spirit, its honesty, its altruism—to use an old-fashioned word, its righteousness. It cries for science to lay down a new foundation for relations among men—a new basis for morals. What an obligation rests on science and what an opportunity is at hand for making its principles living forces in the world! Columbus only discovered a new continent; science has within its power the creation of an entire new world. What of the future of the American Association for the Advancement of Science? Civilization asks the question.

F. R. Moulton

THE PROPOSED PUBLIC HEALTH PROGRAM

In a special message to Congress on January 23, President Roosevelt submitted to the legislature for careful study the report and recommendations of the Federal Interdepartmental Committee to Coordinate Health and Welfare Activities for a national health program. Senator Robert F. Wagner, of New York, stated in a radio address on January 30 that he is now drafting legislation to make this broad-guage plan a national reality.

The program presented to Congress had its origin in the cooperative efforts of federal agencies to make the health and welfare benefits of the Social Security Act quickly and effectively available to the general population. Three years of study on the part of the federal officials who form the membership of the Interdepartmental committee and its technical subcommittees served to focus attention on the uneven distribution of health services and medical care, and on the need for more adequate provision of public health and medical services as reflected in terms of preventable disease and death, costly disability and dependency. Accordingly, a preliminary plan to provide a better distribution of health facilities and medical services throughout the nation was prepared by the Technical Committee on Medical Care and submitted to the President in February, 1938. In July, at the suggestion of the President, a group of some two hundred men and women met with the Interdepartmental Committee in Washington to discuss the proposals of the committee and to facilitate an expression of opinion on the part of the several professions and consumer groups concerned with the provision and receipt of health services.

The recommendations of the committee require objective study. They should be considered on the basis of the statement of needs and of the objectives of the program which forms the opening sections of the report. Dr. John Punnett Peters, professor of clinical medicine of the Yale Faculty of Medicine, recently stated that the program submitted by the committee "bears the marks of statesmanship, rising above political expediency. The problem is clearly defined and measures for the treatment of each major phase are outlined. The federal government is not given undue predominance; administration is entrusted to local and state authorities; proposals are stated in general terms only; the means to implement them and the machinery to execute them are wisely consigned to further discussion and experiment; gradual, evolutionary development is contemplated."

The recommendations of the Interdepartmental Committee lay down four lines of approach which form a coordinated plan for the improvement of national health. They are briefly:

(1) The expansion and strengthening of existing federal-state cooperative health programs under the Social Security Act, with special reference to public health organization, maternal and child health services, the care of crippled children, the control of tuberculosis, venereal diseases, pneumonia, cancer, mental disease, malaria and industrial disease and accident.

(2) The construction, enlargement and modernization of hospitals and other physical facilities for good health, where these are non-existent or inadequate. Federal grants toward maintenance costs of new institutions during their first years of operation are also proposed.

(3) Grants-in-aid to the states to assist them in developing sound programs of medical care which will take account of the needs of all persons who now receive inadequate medical care. The origination, the organization and the administration of such programs are left to the states.

(4) The development of social insurance to provide partial compensation in

DR. THOMAS PARRAN

SURGEON-GENERAL OF THE U. S. PUBLIC HEALTH SERVICE, WHO WAS AWARDED THE WILLIAM FREEMAN SNOW MEDAL FOR DISTINGUISHED SERVICE TO HUMANITY, BY THE AMERICAN SOCIAL HYGIENE ASSOCIATION AT ITS 26TH ANNUAL MEETING ON FEBRUARY 1.

lieu of wages to those temporarily or permanently disabled by disease or injury.

Dr. Thomas Parran, Surgeon General of the U. S. Public Health Service, in an address to the National Health Conference said: "Those of us who are concerned with the progress of medical science usually think that the great events of medicine occur only in the research laboratory or the operating room. We are witnessing here another kind of progress in medicine—an effort to put medical science to work. The National Health Conference may well be the greatest event in medical science which has happened in our time."

The significance of this statement to applied science can not be overestimated. It signalizes the revitalized appreciation on the part of science of its responsibilities for the social advance of the civilization it serves. It foreshadows a fresh impetus to progress in every branch of science. Medicine has contributed discoveries of the utmost importance to the mechanical and biological sciences; it has, in turn, drawn upon the inventions and discoveries of every scientific discipline for the means to further man's attack on disease and death. Only when the contributions of science are used to the fullest extent are new problems set, new demands made, new discoveries possible.

TELEVISION IN WASHINGTON

THE first public demonstrations in Washington of recent developments of television by the National Broadcasting Company and the Radio Corporation of America were made at the end of January. The equipment used in picking up the things that were being transmitted consisted of two units, one roughly like a small tent equipment with Klieg lights and the other looking much like a private railroad car. All this equipment was located on the Mall near the buildings of the Department of Agriculture. The receiving sets were installed in the National Press Building, approximately half a mile distant.

MOBILE TELEVISION UNIT

SHOWING ICONOSCOPE CAMERA AND MICROPHONE, AT THE MOMENT ON TOP OF THE VAN HOUSING THE CONTROL ROOMS, AND THE CABLE FOR PASSING TELEVISION SIGNALS FROM THE CAMERA TO THE TRANSMITTER VAN. SIGHT AND SOUND ARE PICKED UP BY THE ICONOSCOPE CAMERA AND PARABOLIC MICROPHONE AND SENT THROUGH SEPARATE CABLES TO THE CONTROL ROOM.

AMBASSADOR IN PHOTOGRAPH AND BY TELEVISION

THESE TWO PICTURES OF COUNT JERZEY POTOCKI, POLISH AMBASSADOR TO THE UNITED STATES, SHOW THE RELATIVE CLEARNESS OF AN ACTUAL PHOTOGRAPH WITH A REPRODUCTION IN THE ICONOSCOPE DURING THE RCA–NBC TELEVISION DEMONSTRATIONS IN WASHINGTON, D. C.

The "performers" were various persons drafted extemporaneously for the purpose, most of them being well known in Washington. The continually changing audience in the National Press Building consisted of the performers and many other invited persons. The results were not only extremely interesting but excellent. Every person making an appearance was as easily recognized as in an ordinary non-professional motion picture and the reproductions of the voices were entirely satisfactory. Although transmission by wire is used freely from studios to transmitting stations and between cities in our ordinary broadcasting the connection between the field equipment and the receiving sets was only by radio, as it will necessarily be in

many cases when television passes from the experimental to the commercial stage.

At the present time between 75 and 100 receiving television sets are in use in New York by officials of the interested companies, in addition to an unknown number of sets constructed by amateurs. The R.C.A. hopes to have receiving sets available for the public within a few months. In spite of the remarkable success of developments to date, the technical and practical difficulties of television are so serious that its wide use in the future would not appear very promising if we did not have before us the astounding example of the radio. It should be insisted, however, that in television very serious problems are present that do not arise in ordinary radio.

F. R. M.

AGE OF METEORITES

A FEW minutes' watch of the sky on any clear night is almost certain to show one or more sudden streaks of light produced by meteors dashing into the earth's upper atmosphere at high speeds. We know that some of these wanderers from space have been permanent inhabitants of the solar system, for their velocities relative to the sun are less than 25 miles per second. Others of them have traveled the interstellar spaces. The distances between the stars are so great that 15,000 years would be required for a meteor to come from the nearest star to our system if it moved with a constant velocity of 50 miles per second.

Most meteors are so small that the energy of their motion transformed into heat in the high upper atmosphere of the earth entirely consumes them. Occasionally, however, one is so large that it survives its fiery bath and is eased down by the atmosphere to the surface of the earth. These meteorites, as they are called, are often recovered, a few each year, and are preserved in our museums and scientific institutions.

Since meteorites are the only visitors from the celestial spaces, they are of extraordinary interest. Essentially all other information about the universe beyond our earth comes to us through light. One of the questions that always arises when we consider meteors is their ages. The answer to this question, taken together with their chemical and physical constitution, will throw light on their origin and possibly on the origin of the earth.

As is well known, the best method of determining the ages of terrestrial rocks is based on the extent to which their uranium and thorium compounds, if any can be found in them, have degenerated through radioactive transformations. By this method it has been found that certain terrestrial rocks are 1,850,000,000 years old, the most ancient at present known. This is not, however, the age of the earth, for these rocks in which the uranium has been found are intrusions in older rocks.

If meteorites contain uranium their ages can be similarly determined. Fortunately many meteorites do contain small quantities of uranium and other radioactive elements. Dr. Robley D. Evans, 1937 winner of the Theobald Smith Award in Medicine of the American Association for the Advancement of Science for his work on radium poisoning, has recently made a survey of all determinations of the ages of meteors. He states that the typical meteorite contains about one part of uranium in ten million parts of other elements. As soon as the meteorites were formed or became separate bodies their uranium clocks began steadily to tick off the millions of years of their wanderings. According to

investigations of 23 iron meteorites, their ages range all the way from 2,800,000,000 years down to about 100,000,000 years, with approximately uniform distribution over the range. Although there are considerable uncertainties in the determinations, eight of the 23 specimens are older, but not greatly older, than any terrestrial substances whose ages are known.

F. R. M.

DETECTION OF CARBON MONOXIDE IN MEDICINAL OXYGEN

The revision of the United States Pharmacopoeia has become a continuous process. Research on new and old drugs is constantly in progress in the laboratories of the subcommittee chairmen of the General Committee of Revision. Supported by funds from the Board of Trustees of the United States Pharmacopoeial Convention, Dr. Frederick K. Bell has been working on the standards for and the assays of the medicinal gases of the Pharmacopoeia in the Department of Pharmacology of the School of Medicine of the University of Maryland for two years.

The detection of carbon monoxide in medicinal oxygen is an extremely important medicinal problem. The present official method which depends upon the reduction of iodine pentoxide at an elevated temperature by carbon monoxide is non-specific and traces of other substances such as ethylene and acetylene respond positively to this test. The presence of such a large quantity of oxygen makes the carbonyl hemaglobin test far less sensitive than required for this purpose. Dr. Bell has observed that freshly prepared alkaline solutions of sodium hydrosulfite will absorb the oxygen and leave behind the impurity, carbon monoxide, if it is present. Thus by adding a very small volume of nitrogen to a large volume of oxygen and allowing the hydrosulfite to absorb the latter gas, the carbon monoxide may be greatly concentrated in the nitrogen. Besides, most of the oxygen which has an affinity for the hemoglobin is removed. Using freshly drawn dog's blood, Dr. Bell has been able to detect specifically carbon monoxide in oxygen in concentration of 5 parts per million.

John C. Krantz, Jr.

THE USE OF TEAR GAS TO FIGHT WEEDS

Back during the world war, tear gas was one of the weapons of military offense. Many a crucial objective was gained while its defenders were weeping, helplessly, like small boys.

To-day, when strikes and riots prevail, tear gas is the weapon used by police to reduce crowds, temporarily, to non-resistance.

But next year, perhaps, tear gas will find a new use and one far removed from violence. It will help produce weed-free putting greens for the nation's golfers!

J. A. DeFrance, of the Rhode Island Experiment Station, traces the use of tear gas to kill weeds back to the shell-battered No Mans Land of France. The gas squads of wartime contained men trained in chemistry. One of them noticed that where the tear gas liquid spread on the ground, weeds were quickly killed.

Out of this remembrance has come soil sterilization by tear gas which renders the future soil of golf greens free of weeds.

In the present practice the soil destined for the green is placed in a large box and several holes drilled in the earth. Down each hole are poured a few drops of liquid tear gas, a canvass cover applied and left for about two days.

The soil is then removed and placed directly on the golf green and seeded. All the weeds in the soil are killed and the grass takes root without competition from its fast-growing rivals. The putting green is thus free from weed contamination until wind-blown weed seeds alight on it and take root, something which is not too easy when a thick, velvety coat of grass is already there first in husky growth.

Commonest sterilization method for greenhouse soils is the application of live steam while heat, applied by flame, is often used in outdoors locations such as highway roadsides and railroad rights-of-way.

SCIENCE SERVICE ROBERT D. POTTER

MUSICAL ABILITY

You need not be a great composer or an orchestra leader to be credited with the blessing of a musical mind.

Musical talent is bestowed on man in a great variety of forms and degrees, and the ignorant railroad worker enjoying the rhythm of his hammer blows has his share as does the suave critic at the opera.

Underlying all musical ability are the four sensory capacities of apprehension of pitch, loudness, time and timbre, it is pointed out by Dr. Carl E. Seashore, psychologist student of musical talent in analyzing the musical mind as part of his new book, "Psychology of Music" (McGraw-Hill).

These four capacities, and their more complex forms, the sense of tone quality, of volume, of rhythm and of consonance Dr. Seashore calls the four great branches of the musical family tree. They are inborn and are fully developed in the very young child. By the age of ten they can be measured, so that the child's native musical talent can be estimated before his training.

A great musician tends to have these four trunks of capacity branching out in balanced and symmetrical form, but in most of the less distinguished musical minds some one branch is dominant.

Musical achievement does not depend upon great capacity in all these lines, Dr. Seashore says, so long as the individual follows the line of his ability. If a person has only average sense of pitch, for example, he should not try to be a singer or violinist, but he may become a pianist of great distinction.

With the underlying trunk of sensory capacity, the musical mind has the ability to hear with his "mind's ear." He must live in a world rich in auditory images. He must be able to hear over music in memory and create new musical structures in his imagination.

The musician must be able to think musically. He must have musical intelligence.

And finally he must be able to feel musically and express a wealth of emotions in music by esthetic deviation from the regular and rigid.

SCIENCE SERVICE